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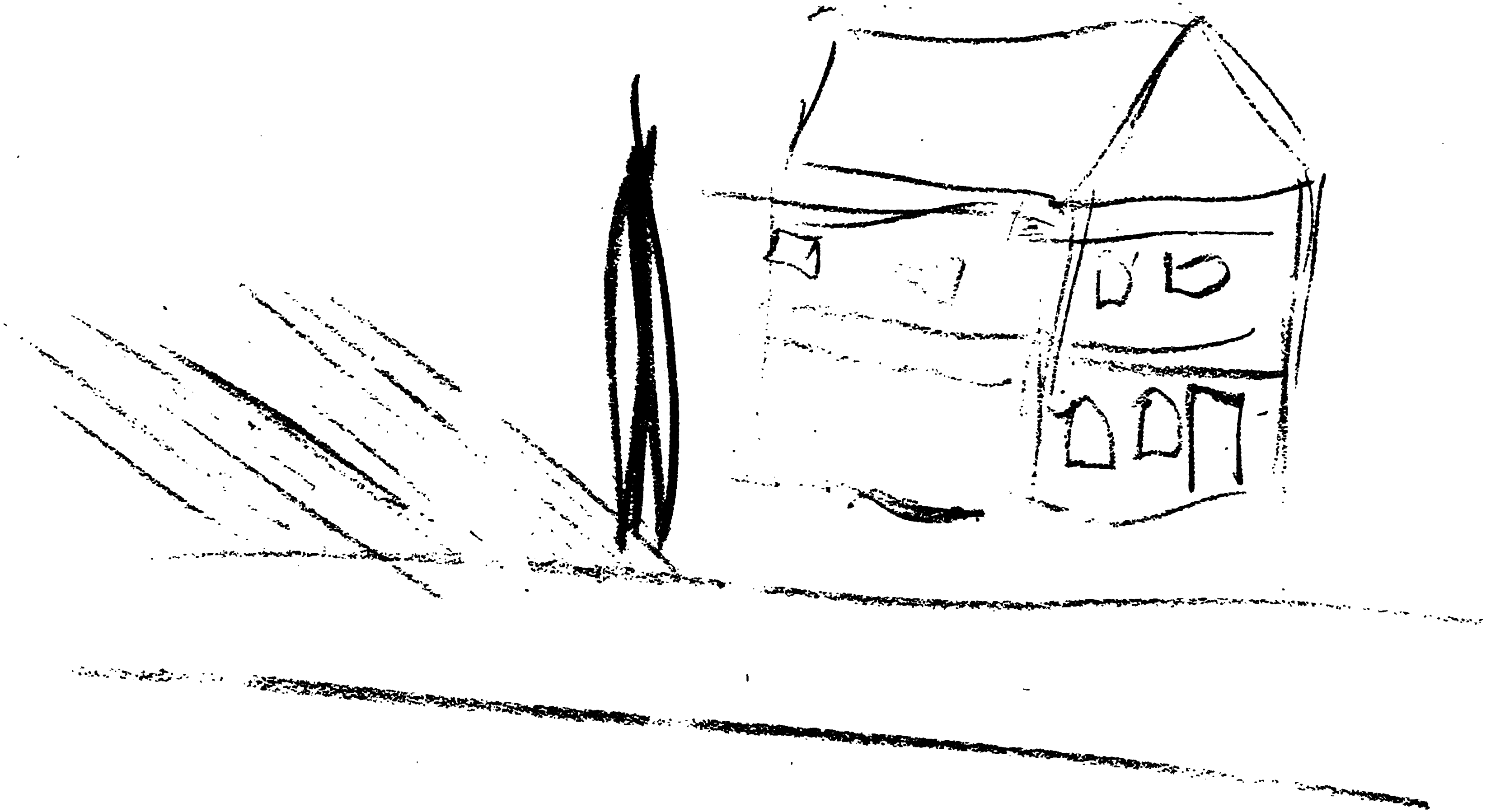

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REPORT OF COAST ARTILLERY TARGET PRACTICE.

ARTILLERY SCHOOL.

FORT MONROE, VA., AUGUST 31, 1901.

The Commandant,
Artillery School, Fort Monroe, Va.

Sir :—

I have the honor to submit herewith a report of Artillery target practice which took place on July 18, last, as a part of the course of instruction in the Department of Artillery, Chemistry and Explosives.

Previous practice.

In March, some practical instruction had been given in fire control, extending as far as to include the duties of battery commanders. It was desired to give the class a practical illustration of the operation of a fire command, using service ammunition at moving targets. Accordingly the ammunition remaining unexpended from the March firing (twenty-nine rounds) was distributed as follows :

Distribution of ammunition.

Ten rounds to Redoubt "B", (five to each gun).
Ten rounds to Redoubt "C", (five to each gun).
Six rounds to Redoubt "A", (three to each gun).
Three rounds to the 10-inch B. L. R., in the Place of Arms.

Assignment of Officers.

The assignment of officers for the firing was as follows :

Fire Commander : Captain Weaver,
Staff Officer at F. C. Station : Captain Strong,
Officers Commanding the Practice :
At Redoubt A, Captain Barrette,
At Redoubt B, Captain Bartlett,

At Redoubt C, Captain Walke,
At Redoubt in Place of Arms, Captain Cronkhite.
Battery Commanders:
Redoubt A, Captain Todd,
Redoubt B, Lieutenant Patterson,
Redoubt C, Captain Pence,
Place of Arms, Captain Winston.
Battery Officers:
Redoubt A, Lieutenant McIntyre,
Redoubt B, Lieutenant Brown,
Redoubt C, Lieutenant Scott,
Place of Arms, Lieutenant Spinks.
Range Officers:
Redoubt A, Lieutenant Farrar,
Redoubt B, Lieutenant Granger,
Redoubt C, Lieutenant Frohwitter,
Redoubt D, Lieutenant Ellicott.
In charge of the Tug and targets: Lieutenant Platt.

Target arrangements. The firing was at moving targets, towed tandem, sixty yards apart; speed, about seven miles per hour; range, from 5000 to 7000 yards.

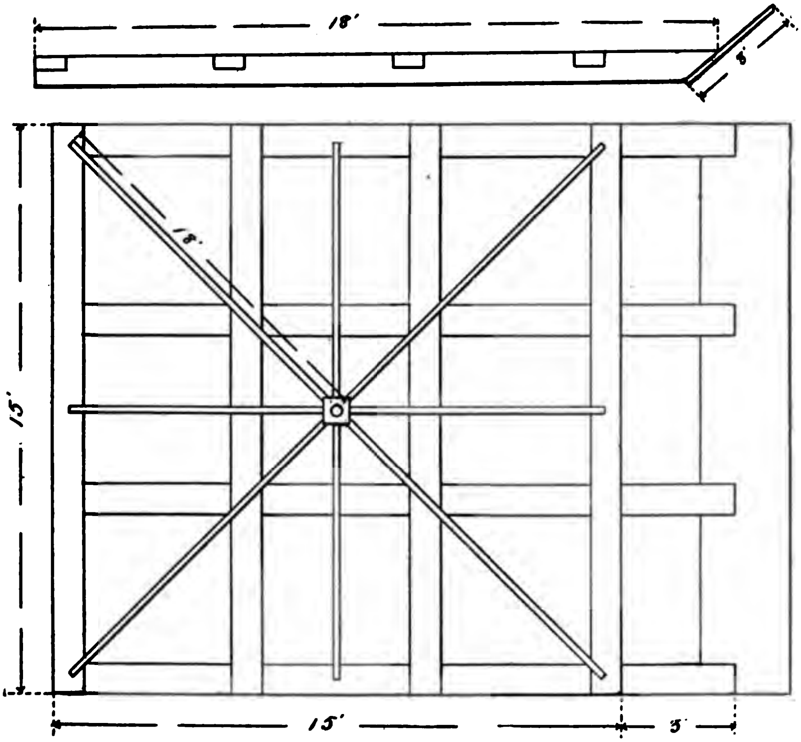
Program of firing. Five series of shots were fired from the batteries as follows:

1. One shot from each battery, from left to right, ordered by the fire commander.
2. One from each gun, ordered promiscuously by the fire commander.
3. One salvo from each battery, ordered promiscuously by the fire commander.
4. At will firing, by all batteries, for five minutes.
5. A single salvo from all the batteries, ordered by the fire commander.

General results. The practice regarded as an experimental test of a fire command was satisfactory, especially in view of the fact that it was the first time a fire command had been operated as a unit, in target practice, at moving targets, at this post.

The accuracy of the firing was not up to the usual standard, but it should be understood that the battery commanders were given no instruction as to the results of shots except what could be observed by themselves, as would be the case in actual service; that a time limit of five minutes only was permitted between the order of the fire commander to fire and the discharge of the gun, or salvo, and that the personnel of the fire control communications was uninstructed in the duties of telephone service.

Description of targets used. The targets used were of the ordinary pyramidal form, except much larger, being 15 feet square on the base and 18 feet on the sloping edge. Instead of being covered with cloth the forms had strips of tin six inches wide placed about them horizontally,



PLAN OF TARGET.

allowing six inches between the strips. The targets constructed in this way offered less resistance to the wind and were more durable than cloth targets. The stringers projected three feet to the front and this end was beveled below and prepared to receive a break water planking ; the object of this was to prevent the target pulling under forward, when being towed. This could be improved, it is thought, by arranging the front so as to have a cut water bow, and such an arrangement would enable the tug to tow the targets at a greater speed. The size and framing, however, answered all purposes well.

List of material for building one target:

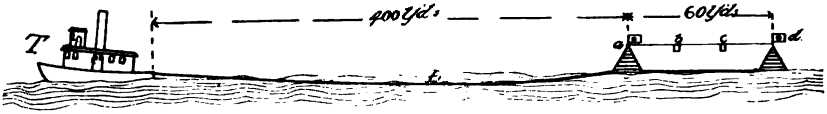
4 pieces of spruce timber 10 x 12 inches x 18 feet,
4 " " " " 2 x 10 " x 15 "
4 " " " " 2 x 10 " x 6 "
4 " " " " 2 x 10 " x 3 "
4 " " " " 3 x 3 " x 18 "
4 " " " " 2 x 3 " x 18 "
500 feet of tin 6 inches wide,
10 pounds of iron spikes 9 inches long,
10 " " " " 6 " "
20 " " wire nails 5 " "
15 " " " " 1 inch long.

Two targets like the above were used; the first one 400 yards in rear of the tug, the second, 60 yards in rear of the first.

This 60-yard interval between targets was equal to one-half the length of the standard ship-target prescribed for target practice. By reducing the distance to 60 yards the target crossed the line of fire in one-half the time it would take a full-length target to cross; this, for deviation allowances, was equivalent to a ship's travel of twice the actual rate. The Tug towed the targets at about seven miles per hour, the rate at which the target crossed the line of fire was, therefore, equivalent to a speed of fourteen miles per hour.

The "overs" and "shorts" were taken by an observer on the tug using a special device for that purpose.

The following figure is intended to represent roughly the arrangement of the tug and targets:



T, Tug, speed seven to ten miles per hour with targets.

L, Tow-line 450 yards to first or bow target, allowing 50 yards for knots and sag.

a, Bow target.

d, Stern target.

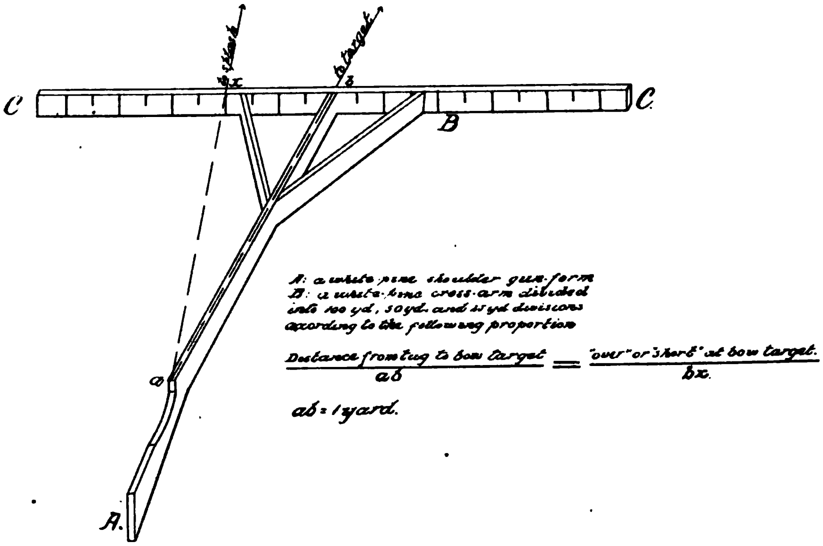
b, c, Two black and white flags suspended from line joining tops of targets; flags 24 yards apart, marking "midship section" of target; 24 yards also is the width of standard ship target.

a–b, "Bow section".

c–d, "Stern section".

Device for taking "overs" and "shorts".

The following figure represents the device used on the tug for taking "overs" and "shorts":

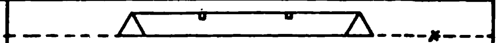
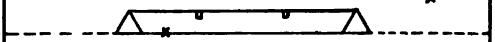
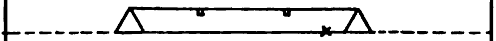
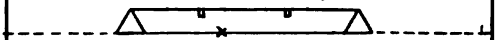
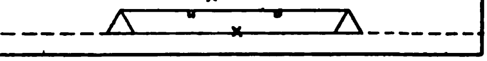

to splash
x
to target
b
C
C
B
A: a white pine shoulder gun-form
B: a white-pine cross-arm divided into 100 yd, 50 yd. and 25 yd. divisions according to the following proportion
Distance from tug to bow target / ab = "over" or "short" at bow target / bx.
ab = 1 yard.
a
A.

In using the device, the observer on the tug, at the instant the discharge of the gun was noted by signal from the shore, held the gun-form against his shoulder, with his eye at the point *a*, and directed the line of sight *a–b* on the bow target. At the instant the splash appeared, he glanced the eye quickly to it, and noted the reading on the cross-arm scale, say, at *x* in the figure. The scale was so numbered that the figures could be seen easily from *a*. It was sufficient to divide the scale into 20-yard divisions for the smallest reading. Splashes falling between these divisions could be estimated with sufficient accuracy. Indeed, it was the general opinion that the "overs" and "shorts" taken in this way were more trustworthy than those taken, as heretofore, by instruments ashore.

Method of taking and recording deviations.

Deviations were taken ashore from a position as near the gun as possible. The bow target was followed using the alidade sights of an azimuth circle, with limb unclamped, zeros together, vernier-plate clamped, left hand on the clamp of the limb, right hand on the tangent-screw of vernier plate. At the instant the splash appeared the limb was clamped with the left hand and the vertical cross-hair brought by the right hand to bisect the splash; the reading was then taken at leisure and recorded, and the instrument then reset and placed on the bow target.

In view of the fact that our present system of target practice counts hits only, it was found to be quite possible to record accurately, for this purpose, the deviation with the unaided eye. It was perfectly apparent whether the splash occurred between the targets, and not that only but it could be seen whether the splash was in the midship section, which, as before stated, was equal to the width of the standard ship target. It was, therefore, possible to record the shot, at once, *so far as deviation was concerned,* as a 100 per cent hit, a 50 per cent hit, or a miss. For this purpose battery commanders arranged a tabulated form as follows:

Shot	Deviation
1	
2	
3	
4	
5	

The cross was made at the relative point the splash appeared to rise. The distances between the targets and flags being known, the deviation, in yards, from the bow target or mid-point could be estimated to very closely.

Modification of towed target.

At the suggestion and under the supervision of Captain F. S. Strong, Artillery Corps, a modification of the arrangement of the towed target was made in firing with rapid-fire guns, the last of the series. Two barrels were lashed to the tow line between the targets, one at each end of the midship section. A piece of target cloth was then stretched between the upper line and the tow-line, filling in the mid-ship section. On this cloth a 6-foot bull's eye was painted. The success of this target, suggested that the arrangement might be extended to fill in the entire distance between the targets, thus representing quite closely the side of a battle-ship. The advantage of such an arrangement would be that the gunner could tell at once whether his shot struck short or over; if the latter, only the upper part of the splash would be seen; if the former, the lower as well as the upper part would be seen. This, too, would be the effect observed in action.

Sailing target for Mortar target practice.

In referring to moving targets, it may be well to mention, at this point, another innovation in the matter of targets, introduced in the regular annual post mortar practice.

It was, of course, not to be considered safe to fire mortars at a towed target. A sailing target was, therefore, used. In 1894, an improvised target of this nature had been tried in target practice with some promise of success, but it was, at that time, ascertained that such a target would have to be constructed on the centre-board or regular keel-bottom principle. In considering the matter, the Ordnance Officer of the post, Captain F. S. Strong, Artillery Corps, arranged to hire a small fishing boat about ¾ ton capacity, agreeing to pay the owner a small sum per day for its hire and to make good any damage that might be done to the boat, not to exceed a specified value of the boat, in case it were destroyed. After some preliminary experiments it was found possible to fix the sail and rudder so that the boat would hold its course, either before the wind, quartering or across it. A ballast of about 1000 pounds of sand had to be placed in the boat when unoccupied, to produce the proper stability in a fair wind.

The 58th Company, Coast Artillery, fired six shots at this target in 25 minutes, using the 12-in.

B. L. M. The course of the target was from VII to I, o'clock, and its speed, as determined from the plotting, about 8 miles per hour. Of the six shots fired two were actual hits on the standard ships' deck target. Three other shots were good, and if pits had been fired instead of one shot, each salvo would, likely, have scored at least one hit. The range was between 5000 and 7000 yards. Attention is invited to the rate of fire. There was no difficulty in firing the series at a 5-minute rate. Indeed, it was necessary to wait for the end of the firing interval, in all cases, after having loaded and laid the mortar. With some modification of the means of supplying ammunition it would seem that a 4-minute rate of fire might be attained. Our groups of 16 mortars in four pits of four mortars each would, with this rate of fire, allow a pit-salvo each minute. A fire of this character would certainly be very dangerous to a ship, if the above is to be accepted as any criterion whatever, and it should be mentioned that the firing last year, with these mortars, at a fixed target, was even better than that given above.

Comments and remarks of a general nature.

The target practice of the School last March, that of July 18, and the regular annual target practice of the artillery companies stationed at the post of Fort Monroe, have all been conducted on the same principles: at moving targets and with the shortest possible time between shots that was consistent with careful laying. Some few points, other than the above, have come to the surface in the course of this practice which, perhaps, may with propriety be presented herein, in the form of comments or notes.

Details of system of position finding and fire deviation.

—Position finder.

—Battery telephone lines

There was but one position finder at the post, a Lewis, type "A", depression finder. Ranges were taken by this instrument and its location was considered the fire commander's station. The azimuths and ranges of targets were sent by telephone to the plotting- room of each battery over a single line on which were all battery stations; no conversation was permitted over this line it being reserved *strictly* for azimuths and ranges. Obser-

Time arrangements.

vations were made each minute. The watches of battery commanders, battery officers and gun commanders were adjusted to the fire commander's time. Azimuths and ranges received at a battery plotting-room were immediately replotted by the battery range officer who was in charge of all work at the battery plotting room with such enlisted men to assist him as were needed in any case, the different arrangements of the several emplacements necessitating modifications. As soon as the position of the target, as given by one set of azimuth and range, was plotted, the range-officer made a prediction for two minutes ahead. The range of this predicted position from the directing gun, with the corresponding time, in hours and minutes, was telephoned immediately to each gun position. The receiver at the gun position entered this in large figures in parallel columns on a black-board; this black-board was so placed that it could be seen distinctly by the battery commander and the gunner. Subsequently a still better method of recording the range-time relation of these predicted positions was approved. It was found that commanders not only wished to know the range at a given time but also the *rate of change of range*, in order, that, if the gun were ready to fire, it might not be necessary to hold the fire awaiting the arival of the precise minute corresponding to the predicted position. Also, from time to time, an abnormal prediction would come up to the gun and the error would not be noticed when entered in the columns on the black-board. To meet these requirements the black-board was divided into blocks by painted lines, the horizontal divisions representing time (minutes), the vertical ones range (50 yards). The man receiving the range-time relation by telephone from the battery plotting-room to indicate this by making a cross opposite the proper range-point on the proper minute-line, *thus a plotted representation of the range-time relation would appear on the board.* Any abnormal prediction would become evident as soon as plotted and could be thrown out. It would be possible for battery

Battery replotting.

—Prediction.

—Range-time relation to each gun position.

—Graphic indications of range-time relations.

—Advantages of graphic indication of the range-time relation.

commanders to fire at any intermediate instant, and, even, if necessary, to project the plotted line forward a minute or two and tell with very close approximation what the next predictions would be. In these respects this method of registering at the gun position, the range, is thought to possess advantages over even the dial indicator, and, especially so as the record is visible at a distance of 40 to 50 feet, whereas, with a dial indicator, the record can, as a rule, be read only a few feet from the dial. The time divisions on the blackboard need not exceed ten in number, and the range divisions twenty, corresponding to an interval of ten minutes and to a change of range of one thousand yards. The black-board should be placed well to the front in each gun position where it can be seen by the gunner from his position on the sighting platform.

Firing by Case II. All firings with guns were conducted according to Case II. of the Drill Regulations. Settings for range being made by the elevating arc ("quadrant" angles) and the direction being regulated by the gunner, using the telescopic sight.

Deviation allowances. Gunners timed the rate at which the target crossed the field of the telescope, in terms of the smallest division of the deflection scale, and were thereby able to make allowances on this scale for the motion of the target across the field during the time of flight. Gunners were given or committed to memory the times of flight *for the even thousand and half-thousand yards.* The range being constantly in evidence before them, enabled them to keep the deflection scale set for motion of target during time of flight across the field; to this was added or subtracted the corrections due to other causes (drift and wind).

Results as to deviation. The results of the firing led to the conclusion that the problem of deviation is not so difficult as has been supposed. The deviation record of 127 shots from all calibers, at ranges varying from 3000 to 7000 yards, at targets moving across the plane of fire at a speed equivalent to about 14 miles per hour, shows that 81 shots went within the "midship" section (12 yards each side of the middle point), 30 shots within the "bow" and "stern" sections (18 yards next to midship) and only 16 outside the 60-yard distance between the bow and stern targets. These results may be tabulated as follows:

Total number of shots in series.	Within bow or stern section.	Within midship section.	Misses.
10	3	7	0
10	2	8	0
5	4	0	1
5	3	2	0
5	4	0	1
5	3	1	1
10	3	4	3
10	1	7	2
10	0	01	0
6	2	4	0
6	0	4	2
10	1	7	2
10	2	6	2
10	1	8	1
5	0	4	1
5	1	4	0
5	0	5	0
127	30	81	16

That is 87.4 per cent of the splashes were within 60-yard limit between targets, 63.7 per cent being in the midship section and 23.7 per cent in the end sections.

The mean range-error of five companies, firing with the 10-in. B. L. R., 8-in. B. L. R., and 8-in. M. L. C. R. was 165 yards, scoring about* 30 per cent hits on the standard target.

It should be kept in mind that this firing took place for the first time with a time-limit firing-interval of two minutes; that no information was given to the battery commanders as to the error of range after the first two shots; that the powder was not uniform in pressure, and that it was the first time that most of the officers and men had fired at moving targets.

The ranges of the target varied from 3000 to 7000 yards.

Considering the problem of deviation apart from that of the range, it is believed that this firing shows that with a little practice our gunners will be able to attain to a very high standard.

---

* The exact replotted data are not yet available in all cases.

The problem as to range.

Indeed the *deviation* question appears to be far in advance of that of range. It is therefore important to watch carefully all factors affecting range. It would seem that we ought, in these days, to have a right to expect to be furnished with powder possessing fairly uniform properties.

Probably this will be the case when smokeless powder is furnished by the Ordnance Department as contemplated by G. O. 36, H. Q. A., 1901. The brown prismatic powder which has been used in all the firing with large guns during the past year has been found to give evidences of variable rates of burning.

Importance of identical conditions in loading.

Bearing on this same point is the importance of producing identical conditions in loading; every thing that goes to affect loading conditions has an influence. There is a greater chance for error of range in the loading conditions than in error of laying. With the old 8-inch C. R. it was found that a difference of ½ inch in the distance of the base of shot from the bottom of the bore would make a difference of 25 f. s. in the muzzle velocity. If such a variation were to occur in firing the 10-inch B. L. R., it would be equivalent to an elevation angle of 9′ at 6000 yards, or, converted into range, almost exactly 100 yards. It is suggested that breech-details should be selected with great care; that the men assigned to these details be permanent in so far as possible; that at drill some device be arranged that will enable breech details to practice ramming actual projectiles; that powder bags be handled with great care so as not to distort or stretch them; that the projectiles be sent home with the same force each time.

Duties of the battery Commander.

The firing has made evident the necessity of some modification in the duties of a battery commander as prescribed by the Drill Regulations.

—His paramount function.

It has been found that the paramount function of the battery commander is that of *general* supervision, and direction of the workings of his entire command. From the fire commander above and from all divisions of his personnel below he is called upon to do or to direct. He must be in position to give his attention to *any* or *all* matters which may happen to be presented to him.

—Not advisable to assign to him special functions.

If he be assigned to any important special function, as he is by the drill book, that function is sure to be interrupted by the pressure of general matters, and, as a consequence, the entire process may be arrested. He should not be given any one particular function to perform, such as computing the corrected range, or transmitting this to the gun. All such special duties should be assigned to subordinates.

Battery Commanders Station.

The battery commander's station should be so placed that he may be able to:

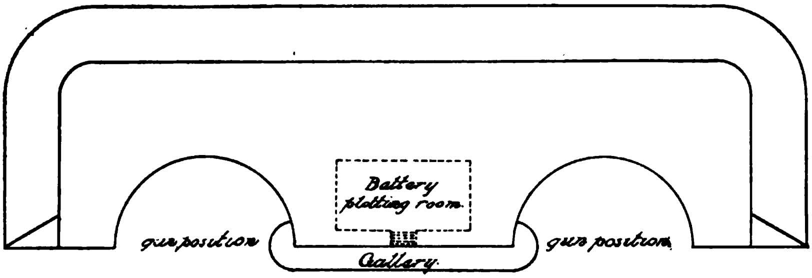
1. See the target and the effect of his fire.
2. See the men at the guns, the loading and laying of the guns, and observe that the personnel perform all duties in accordance with the requirements of Fire Discipline (p. 111, D. R.).
3. Have direct and convenient access to the battery position finder or plotting-room.
4. Be in instant communication with each gun position, each ammunition hoist and the fire commander.

Various locations of battery commander's station in our works.

Much inconvenience and confusion has resulted from the various methods followed in the location of battery commander's stations in the emplacements of our guns.

Suggestion for a two-gun emplacement.

Assuming a battery of two guns, it is believed the above conditions would be most nearly met by placing the battery plotting-room in the traverse between the guns, connecting with a gallery along the interior wall passing from one gun position to the other, this gallery to constitute the battery commander's station. This may be shown roughly in plan by the following figure.



The battery commanders' instrument for the observation of fire may be placed conveniently on the parapet.

Fire Commander's telephone line. The fire commander's telephone line should lead to the battery commanders' station.

Battery communications:—Hoists. A telephone line should lead from the battery commanders station to each ammunition hoist.

—Plotting-room. If the position finder be not coincident with the battery plotting-room a telephone line should connect the two, over which azimuths and ranges only should be sent, a second line being introduced for *general* conversation.

—Gun positions. A telephone line should connect the battery plotting room with each gun position over which ranges would be sent for the black-board range-indicator. In case the dial indicator be used it would supplant this telephone line.

Speaking tubes not efficient. Speaking tubes are not an efficient means of communication when *speed* is an important consideration. Moreover it is as difficult to get men to speak clearly through a tube as into the telephone sender. Both speaking tubes and telephones were tried during the firing and the latter were found to be far superior as to distinctness, speed, and convenience.

At times, telephones were used in the gun positions and worked satisfactorily.

Importance of specialists in personnel. It is very important that a certain number of men be trained to the use and care of telephones. Indeed, the importance of a differentiation of the personnel of coast artillery, among the several divisions into which fort defense may be divided, becomes more and more apparent. Modern requirements call for an instructed personnel for:

Classification of personnel.

1. Gun service. (This we may be said to have.)
2. Torpedo service.
3. Communication service.
4. Position finder service.
5. Power and light service.

The relation of the fighting unit to the unit of instruction and administration. Accepting the fire-command as the fighting unit in coast defense, the call to arms would send the manning force of a fire command to posts that would naturally, divide, as to duties, along the lines here indicated. The question arises, why should not *instruction* and *administration* follow the same lines of cleavage? Cannot the garrison of a fire-command be taken as the unit of administration? It would be more economical to administer and more adaptable to instruction and service. The "company" of 109 is as much of a misfit to fire-command duties as the regiment was to the general duties of coast defense. It is believed the logic of the situation suggests that either the company be made a *variable* unit to fit the services as above indicated, which the present law would seem to authorize, or that the company as now constituted be modified by law.

Not advisable to have the "company" a fixed unit.

As matters now stand the companies are assigned to the service of certain guns and the other divisions are provided for by details. The men so detailed look upon the work as a side matter and this is shared to some extent by their officers. If a high standard is to be attained in the new services we must have torpedo-companies, communication-companies, position finder-companies, power and light-companies, of variable numbers and composition, each under its own officers, to be instructed in a special way, along the respective lines laid down above.

The "detail" system not conducive to high standard in garrison instruction.

The necessity of practice at moving targets entails the necessity of adopting some motive power to move the targets. It is believed that, for guns, the towed target as described above, will give satisfaction. In order that ship tracking, simulated firing, sub-caliber practice and full caliber practice may take place regularly, progressively and continuously, each artillery district should be furnished with a good sea-going tug for these purposes. The tug should go into the field of fire regularly during the drill hours with the targets in tow, so that practice of any kind may be had by the men at the guns. These tugs should also be equipped for submarine mine work, and for the latter work should have a platform scow tender with a platform capacity sufficient to carry a grand group of mines, with cables, etc. It will be more economical for

Need of sea-going tug in each artillery district to tow targets regularly over the field of fire during drill hours.

the United States to have its own tugs for these purposes than to attempt to hire them.

Disadvantage of hired tugs.

Furthermore, a better service will be obtained. Much difficulty arose throughout the firing here from the vagaries of the civilian pilot of the hired tug. He apparently was not interested in going at a good speed. From time to time he would execute maneuvres which were time consuming and apparently not obligatory. A tug for these purposes should have a draft of about 9 feet and a towing speed of about 10 miles per hour.

Telescopic sights deficient in light and power.

The telescopic sights were found to be deficient in light and power. On several occasions it was possible to see the target with the naked eye when it could not be seen through the telescope of the sight. It is thought that a higher power would give better results with coast guns. It is required also for safety to detect small boats beyond the range of the target; sometimes it is very difficult to see small boats on the water at 8000 to 9000 yards, and ricochet shots may reach such ranges.

Suggestions.

It is, therefore, suggested that a telescope having about a 3-inch object glass with a power of about 14 would improve all gun shooting and increase the safety of the firing. There is such a telescope at this post, now on the Squier-Crehore horizontal base experimental position finder, which, it is agreed, would give excellent results as the telescope of a sight. Such a sight should be mounted on a standard separated entirely from the carriage. It should be so mounted as not to be endangered or thrown out of adjustment by the shock of discharge. It should have an "open" bar sight attached to it for roughly following moving targets and for use at short ranges. Its vertical cross-hair as well as its horizontal cross-hair should be divided into "points" so that the gunner could use it as a range finder in case the standard system should, for any reason, collapse. The division of the vertical cross hair into points would enable the gunner to compute with close approximation the value in yards of "overs" or "shorts" in target practice or service firing.

"Open" bar sight attachment for each telescopic sight.

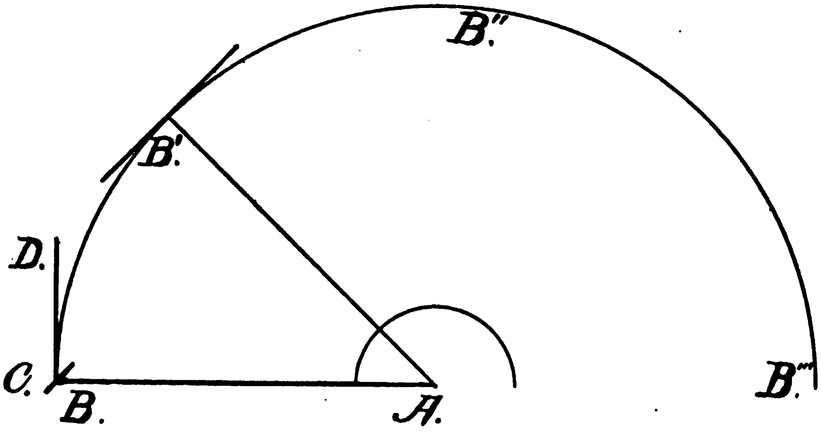
Vertical base and long horizontal base position finders not always satisfactory.

The vertical base position finder is not suited to a low coast line. The long base horizontal instrument is not to be relied on when several targets nearly alike are in the field of fire. The former is too conspicuous an object, and would be speedily knocked out by the enemy's rapid-fire guns; the latter is almost certain to develope confusion in observations due to the difficulty of the observers in selecting the same target, in taking observations at the same instant, and in shifting promptly and certainly at a signal to a new target.

A fair degree of accuracy is obtained with a vertical base of 50 to 70 feet. With this result established by our practice it is said as good results could be had with a horizontal base of 30 to 50 feet, since the latter would be free from inaccuracies due to variable level of the tide inshore and out in the field of fire, and from those due to atmospheric refraction. Having this object in view a suggestion is ventured herewith for such consideration as it may merit.

Suggestion as to a self contained horizontal base position finder.

A self-contained horizontal base position finder might be constructed on the following principle:



Let *A* represent the position-finder center, at which a good telescope is mounted on a substantial plotting table with azimuth graduations. At *B*, at a distance, say, of 50 feet from *A*, let a circular track be laid down having *A* as its center. On this track mount a carriage that shall carry a second telescope in a fixed position, so that its line of collimation shall always be perpendicular to the radius of the circle at the point where the carriage may be. This carriage to be provided also with a seat to carry the observer at *B* and the motion of the carriage to be controlled by this observer either by hand-power or foot-power, or both, so that he may be able to bring the telescope to bear on any point in azimuth by simply moving the carriage over its track.

The telescope at *B* should have two adjustments:

1. To make *AB* equal to the exact length of the standard adopted for a base, say, 50 feet. (The extreme limit of length of base would be the distance observer at *B* could be directed in ordinary voice by observer at *A*). This adjustment would be made by placing an oblique mirror at the point *C*, attaching to the telescope a sighting rod *CD*, then seeing *A* by reflection and *D* by direct sight bring images to coincide, the coincidence being exact when *AB* is 50 feet.

2. To make the angle *ABD* a right angle. This may be accomplished by a second mirror at *C* at 45°. *ABD* will be a right angle when reflected *A* coincides with *D* directly.

When these two adjustments are made it is evident that the base *AB*, the line of sight through *A* and that through *B* will form a right triangle, the solution of which may be made mechanically on the plotting table at *A*. It is not necessary to give the details of this solution in this bare presentation of the fundamental principle involved.

The track *B* might be sunk below the surface of the ground or covered with a glacis slope. The station proper at *A* might, likewise be arranged in a pit or covered by earth or concrete. Both *A* and *B* should be so housed as to be invisible at combat ranges and this effect assisted by shrubery planted in rear of them.

Such a self-contained horizontal base position finder could be placed on either flank of a battery with telephone connection with the battery plotting room, if the latter be not placed in connection with it at the point *A*.

Search lights necessary for night practice.

It is important that electric search lights be installed as soon as possible. Night practice, especially with rapid-fire guns against a simulated torpedo boat attack on the inner harbor is now impossible. Each battery commander should have a 30 to 36-inch search light as an essential part of the battery's outfit. A battery commander cannot depend on an adjacent light without impairing the efficiency of his guns. If one light be made to do service for several batteries the work of each is to some extent under a restriction and the efficiency of the whole lowered.

Miscellaneous notes:—

Some notes of a miscellaneous nature have been made from time to time during the practice which may be grouped here:

Difficult to replace misfire primers with disappearing mounts.

1. In case of misfire, with guns on disappearing mounts, it is very difficult for the cannoneers to get to the breech of the gun to remove the old primer and to insert a new one. A ladder or platform should be provided at one side to enable this to be done expeditiously.

Screw threads for obturating primer should be slotted.

2. Too much time is required to screw in the obturating primer; it takes fourteen separate movements of the hand occupying about a second each; it is suggested that the male and female screw of the primer and its seat be *slotted*, so that by inserting it and giving it one turn the primer would be fixed completely for firing.

—Breech blocks worked stifly.

3. All of the breech blocks worked stifly after a few shots in rapid firing, the difficulty increasing as the firing continued, until after six or eight shots it often took the combined effort of three or four men to force the block in through the last few inches and to lock it. The difficulty lies apparently with the gas-check pad which does not recover its initial diameter after the pressure of the powder gases on it, and with each discharge becomes more and more flattened longitudinally and extended radially. It has been suggested that oil and other liquid may enter between the surfaces of the gas check pad, the rear of the mushroom head

and the front of the breech block and that the pressure of the powder gases would operate to produce a "sucker" effect between these surfaces and hence hold the pad in a compressed state and prevent the free turning of the obturator. Another theory is, that the elasticity of the pad is lost, either due to the melting of the tallow, which is a constituent of the filling, by the heat due to firing, or from age, or from some error of mixing. In any event it would seem advisable to have this matter examined into experimentally. It is believed that no oil or liquid of any kind should be permitted to get between the gas-check and adjacent surfaces, and it is suggested that the surface of the pad be covered with powdered talc (French chalk) or graphite.

—Good lubricating oil needed.

4. A good lubricating oil is very much needed. Ordnance Mechanic C. E. Holmes, suggests a mixture of ⅔ lard oil and ⅓ cylinder oil.

—Hydroline oil.

5. The new hydroline oil for recoil cylinders appeared in certain cases to give results different from the neutral oil formerly used. For the same setting of the throttling valve the hydroline oil seemed to allow a heavier recoil than neutral oil. With full service charges and the throttling valve at its smallest reading the gun at times hit the buffers hard, on recoil.

—Loading platforms too narrow.

6. The loading platforms in most cases are not wide enough. The handle of the rammer extends to the rear over the railing and cannoneers get their hands pinched and injured in forcing the projectile home.

—Naval methods of supplying ammunition and mechanical rammers suggested.

7. In view of the importance of reducing the loading interval of time to a minimum, the question of ammunition service comes to the front with special prominence, The rate of supply on war vessels is much greater than in our forts. Abroad the tendency is to introduce naval methods of supply in forts. Ammunition is delivered directly to the breech of the gun in any position and forced home by a mechanical rammer. This latter is of special importance as it insures the same force each time in inserting the projectile. There

would appear to be no reason why *what is possible and important* should not be obtained in our forts.

—Electric motors and firing device for gunners to operate.

8. The gunners' sighting platforms should be furnished with keys or rheostats operating electric motors for giving elevation and direction to guns, and for retracting them from battery. There should also be at hand on these platforms a pistol-grip firing device, so that the gunner may fire the gun electrically himself. With arrangements of this nature the gunner of large-caliber guns should be able to lay and fire his gun with great precision and rapidity. Such arrangements have been in use on ships for some time.

Sighting platform disconnected from carriage.

9. The gunners sighting platform should be so detached from the carriage proper as to be protected against the shock of discharge, and to make it possible for the gunner to keep his eye on the moving target continuously during the laying and firing.

—Larger object-glasses and greater power for telescopic sights.

10. Telescopic sights for large caliber guns should have larger objective glasses and greater power. Experience would suggest a 2.5 to 3-inch objective with a power of 14.

"Open" bar sight attachment for telescopic sights.

11. There should be an "open" bar sight attachment to all sights for roughly following moving targets during loading, and for use at short ranges.

—Vertical cross-hair of telescopic sights divided into "points".

12. The vertical cross-hair of telescopic sights should be divided into "points" to enable the gunner to determine the range approximately at any time, and to determine also the value of "overs" and "shorts" in target practice or service firing, using the stadiometer method.

-Battery plotting room predictors.

13. The actual range of the target from the directing gun should be predicted every minute on the battery plotting table for a point two minutes in advance, and this range and the corresponding time sent to each gun position. This range and time relation should be instantly recorded in some visible form at the gun position either by a dial indicator system, or by a man, with head telephone receiver, indicating the same on a blackboard.

—Careless handling of cartridge bags.

14. Cartridge bags are carelessly handled by cannoneers; they thereby undergo distortion and

the condition of loading is modified. It is suggested that some form of handling tray be used, a board with cleats on the side was used in the firing by some companies.

—Projectiles not uniformly forced home.

15. Breech details do not force projectiles home with the same force each time. This affects density of loading and other initial conditions.

-Sections of cartridge bags should touch from rear to front.

16. Sections of cartridge bags should be so made for either full or practice charges that when placed in the gun, they should touch, from front to rear, from the mushroom head to the base of the projectile.

—Cross-cut for black prism priming.

17. When the "priming" of the cartridge is accomplished by black prismatic powder inside of the cartridge bag, the end of the latter should be cut crosswise and the ends of the flaps of the cut turned back so as to expose the black grains, thereby better insuring ignition.

-Wire not inserted in vent or seat of primer.

18. The priming wire should not be used in the vent or through the seat of the primer, unless it become necessary to remove an actual obstruction.

—No liquid on mushroom head during firing.

19. Neither water nor oil nor any liquid should be placed on the mushroom head during firing.

-Means of leveling carriages without dismounting guns or dismantling carriages.

20. All gun carriages should be provided with means for leveling the carriage, in case they should get out of level slightly due to settling of emplacements, contraction of concrete in drying or other reason. It ought not to be necessary to dismount the gun or to dismantle the carriage, to restore its level.

21. There is one very serious defect in all of our posts so far as observation has extended. No adequate attempt has been made to conceal the works by planting trees or shrubbery. Trees planted back of works and shrubbery on the slopes and between batteries makes it almost impossible to pick out the location of guns when viewed from the sea.

Respectfully submitted,

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Captain Artillery Corps,
Instructor, Department of Artillery,
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NOTES ON RAPID-FIRE FIELD ARTILLERY.

TRANSLATED FROM THE FRENCH BY CAPT. W. W. GIBSON,
ORDNANCE DEPARTMENT, U. S. ARMY.

NOTES ON THE CONSTRUCTION OF ORDNANCE.

Washington, April 1, 1901.

III.—RAPID-FIRE FIELD ARTILLERY OF EUROPEAN ARMIES, 1900.

[From Publication of R. Chapelot & Co., Paris.]

GENERAL DISCUSSION.

For a long period the necessity of replacing existing systems of field artillery in use in the various European armies by rapid-fire artillery has been discussed. The discussion, very complete, very profound, but rather theoretical, dwelt upon the conditions which should be fulfilled by this new material, so that it could be substituted in the most advantageous and practical manner for the existing material. At the same time numerous constructors or inventors were taxing their ingenuity in solving the problem and advancing its progress. It would take too long to give a list of the private establishments who have proposed new and varied models satisfying more or less completely the general conditions that were proposed. Gradually the different governments followed this movement, keeping in touch with the experiments and making their own, then, more or less secretly, they were led to make the necessary dispositions, so as to be able to adopt at the opportune moment a system of field artillery conforming to the general ideas which prevailed regarding the new explosives and firearms. The "*Journal des Sciences Militaires*" has given (September and October, 1895) a statement of the question regarding this new material and has shown that the consideration of expense was the principal cause of delay connected with the radical transformation of existing artillery. The solution was not urgent so long as a great power had not given the signal. However, in just the same way that changes to small-caliber rapid-fire muskets took place, it was only necessary for one army to take the initiative for others to be obliged to follow in this same way, in order not to be found in a condition of marked inferiority. At the present time the question has passed from the domain of theory into that of practice. Germany, having attempted to transform its existing material, decided upon the adaption of a complete system of rapid-fire artillery, designated by the name of "model

1896." Other powers, as we have seen, were ready to follow the movement and had in principle decided upon a type which could be introduced as soon as they judged necessary, while endeavoring to perfect it up to the last moment. For all of them, more or less, studies have been pushed with the view of having the solution of the question all prepared either by the adoption of new material or by the transformation of the old or by a combination of the two methods. The different models adopted, except in the case of Germany, are surrounded with an almost impenetrable mystery, but not to such an extent as to prevent us from giving some fairly clear notions of the ideas prevailing among the powers which nave decided to modify their field artillery. There are some general statements which we believe it prudent to sum up as exactly and as clearly as possible, while recalling how the ideas have been brought out and what principles have prevailed.

GENERAL PRINCIPLES.

After the war in 1870 an effort was made to improve field artillery, at first by increasing its power, which resulted in making the material heavier, and consequently diminishing its mobility. Then projectiles were perfected to such an extent that they were three or four times more powerful than formerly, due to the substitution for the ordinary shell of a shell containing a large number of balls whose numbers were constantly increased. It was then noticed that this last result could be obtained without loss of any mobility of material, and the effort everywhere was made to find for a powerful projectile a material both mobile and having rapid fire. The question of the efficiency of projectiles had then almost been completely solved. It was easy to obtain mobility of material by diminishing the caliber, which could be done while still preserving for the piece sufficient power. There only then remained the question of increasing the rapidity of fire, and, as has been said, various means could be employed to obtain this result. In the first place an effort was made to increase the rapidity of loading, particularly by uniting the projectile and the charge, as is done in the small-arm cartridge. The employment of a line of sight quite independent of the gun has permitted the rapidity of pointing the piece to be increased, for while the piece is being loaded the gunner continues to follow the objective. To facilitate returning to battery an effort was made, if not to suppress, at least to limit the recoil. The employment of a trail spade, a very simple solution which was thought of at first, was not practical with the "rigid carriage."

It had to be recognized that pointing in direction was difficult, since the material was subject to violent shocks, which in a short time broke it up, without considering the objection of adding a certain weight to a material already too heavy. With a view of correcting these objections, the idea of replacing the "rigid carriages" by carriages with recoiling parts was conceived of; that is to say, carriages composed of several parts movable with respect to each other. An elastic connection is generally interposed between the gun and the point of support furnished by the trail spade. It has for its object not only the returning of the piece to its initial position, but further, which is more difficult, of preventing the jumping of the wheels. The different carriages, then, with recoiling parts, can be divided into two principal types: First, the system with a pivot; second, the system with traverse along the axle. In each case the character is determined by the manner in which the direction is given to the piece. In the pivot system the main carriage carrying the trail spade and the axle is connected by a vertical pivot to a small carriage placed on the preceeding one and carrying the gun. Generally an elastic union is interposed between the gun and small carriage. Direction is given to the piece by making the small carriage pivot on the large one. This system presents the objection in the most general case of causing a slight displacement of the wheels under the force of recoil, which changes the pointing. After a fire of some duration the small carriage will no longer suffice to give the wished-for direction to the piece, and it will be necessary to displace the spade. In the system with traverse along the axle, the main rigid carriage carries the trail spade, but not the axle; the latter slides in a transverse groove cut in the front of this carriage. The gun is supported by a cradle mounted upon the main carriage, which is allowed a movement from front to rear without changing the pointing. An elastic connection is placed between the cradle and main carriage. To give direction the main carriage is made to slide along the axle by a rack and pinion, so that it is the carriage proper which pivots around the trail, without sensibly displacing the axle. The system complete (gun, carriage, and limber) weighs at the most 1,800 kilograms; that is to say, it preserves excellent conditions of mobility in all cases. A caliber of 75 milimeters has been accepted as a mean below which it would be hazardous to go, on account of the risk of diminishing the efficiency of fire, for the projectile would no longer have sufficient capacity to contain the necessary number of balls, and its point of burst could not be surely observed. Moreover, the improvements made in explosives have allowed us to obtain destructive effects much greater than with the old projectiles, although they were heavier. Thus, owing to the improvements in ballistics, we have been able to increase both the length of the shell and the weights of projectiles of small diameter; but to keep the gun easily handled, we ought not to give it an excessive length. Shields intended to protect the cannoneers against musketry and shrapnel fire have their advantages and their objections. They allow the cannoneers to remain calm under fire, and the piece to continue longer in action against approaching infantry; but they increase the weight of the material, which is an objection, and they afford a good target for the enemy. Nevertheless they are in favor. With rapid-fire guns it is not possible to obtain a very great initial velocity, for as regards the weight which can be given to the gun, the recoil could not be suppressed with an initial velocity exceeding about 500 meters, unless we give the carriage unusual proportions, such as General Englehart proposes. No effort is being made to realize "unity of caliber," the Germans themselves recognizing the fact that this idea must be given up, and that two pieces at least are necessary: One light, very mobile, for direct fire, and having a caliber sufficient for ordinary objectives; the other heavier, not so mobile, for curved fire, and sufficiently powerful to overcome the most resisting obstacles. In a word, the same piece can not combine lightness and power. This is the reason why, besides the ordinary fieldpiece, the military powers have adopted a piece of larger caliber; in France the 120 short, in Germany the field howitzer of 15 centimeters; and it seems that this last caliber should not be exceeded for this sort of piece. In the same way that it was impossible to arrive at unity of caliber for guns, it was not found possible to realize unity of projectiles for fieldpieces. It was found necessary to adopt two new kinds of shells. The first, a shrapnel, with a case of steel relatively thin, containing a large number of balls. The bursting charge, embedded in the rear of the projectile, launched the balls in sheafs. This projectile was intended to act against troops through its balls and its fragments, although also acting by shock against obstacles. The second shell is loaded with high explosives, and acts particularly against obstacles by shock; but its feeble capacity limits its efficiency. One of the necessary consequences of rapidity of fire is the increase in the expenditure of ammunition on the field of battle. This difficulty was partly remedied, profiting by the general alterations in field material, by lightning the new carriages, while giving them sufficient resistance, so that with the same number of horses a larger number of projectiles could be transported, and, moreover, as the latter are lighter than the old, a much larger supply than formerly was available. But this would only be a partial remedy if there had not been found another means of providing a more complete one by reducing the number of batteries, or by making use of automobiles under certain conditions. By taking account of the preceeding considerations, it will be easier to follow the information that has been collected on foreign material.

GERMANY.

FIELD ARTILLERY, MODEL 1896.

An imperial order dated March 27, 1897, prescribed the adoption for the German army of the new system of field artillery which will be designated by the name "model 1896." Up to that time there was for this army a unity of model, it is true, but comprising three kinds of guns and two models of carriages and limbers. There no longer exists but a single model. The piece for horse batteries differs from that of mounted batteries only by the omission of seats for the cannoneers, which results in a diminution in weight of 30 kilograms.

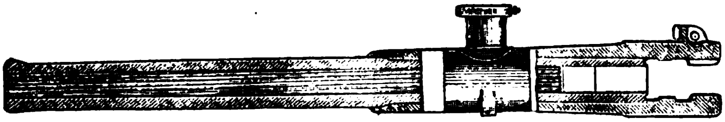


Fig. 1.

Gun (fig. 1).—The gun is of nickel steel (Krupp metal) and is composed of a tube reenforced at the rear by a jacket. The latter is prolonged to the rear in such a way as to form a housing for the breech mechanism. All the left part of the breech has been cut away to facilitate loading. The gun has a trunnion solid with the jacket, which has its bearing in a rocker attached to the carriage. In the interior the tube has 32 rifling grooves of an increasing twist with a final inclination of 70°. The shot chamber, which is rifled, is united to the powder chamber by a forcing cone against which the band of the projectile strikes. The caliber is 77 millimeters and the total length of the tube is 27 calibers (1.079 meters). The sight slot is arranged in such a manner as to correct automatically the normal drift corresponding to the range.

Breech Mechanism (fig. 2).—This mechanism consists essentially of a flat wedge which moves horizontally in the bridge recess. The wedge is provided internally with a mechanism actuating the firing pin, which is armed automatically when the bridge is opened. Obturation is assured by a metallic cartridge case whose base is supported when the breech is closed against a steel plate carried by the wedge and pierced centrally for the passage of the firing pin. The case is seized by the hooks of the extractor in front of its flange. The breech is opened by sliding the wedge to the right instead of to the left as formerly, which facilitates loading. The wedge is maneuvered by means of a breech screw as in the old gun. The long arm of the handle has a safety button to keep the breech closed during movements and to prevent the accidental discharge of the piece (fig. 3).

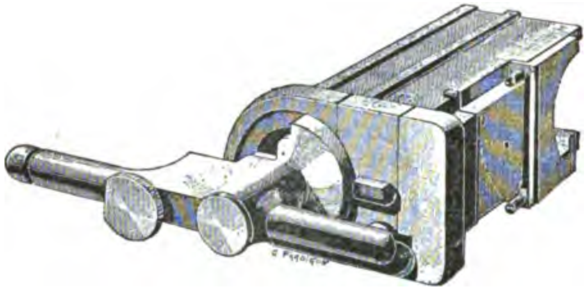


Fig. 2.

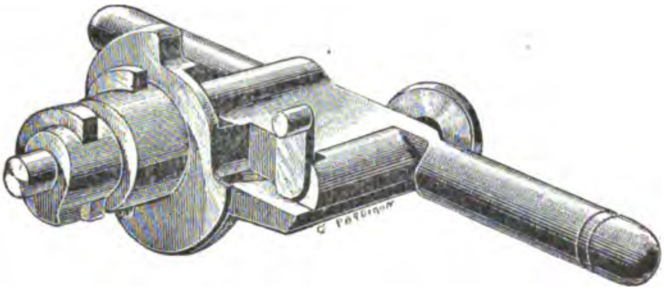


Fig. 3.

The piece is loaded by introducing a projectile through the rear, along the axis of the gun. The cartridge is pushed in by hand until the flange of the case strikes against the claws of the extractor. A breech cover protects the breech mechanism against dust during marches.

Rocker (fig. 4).—This arrangement, intermediate between the gun and the carriage, allows the gun to be given a small displacement with respect to the medium plane of the carriage.

The mechanism for pointing in direction consists of a screw which, by its horizontal movement in a nut united to the rocker,

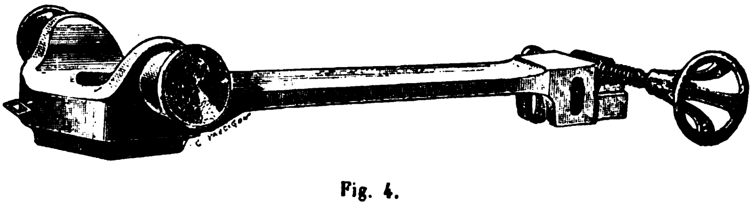


Fig. 4.

carries with it the gun and makes it pivot on the rocker. The mechanism for pointing in elevation is indicated in fig. 5.

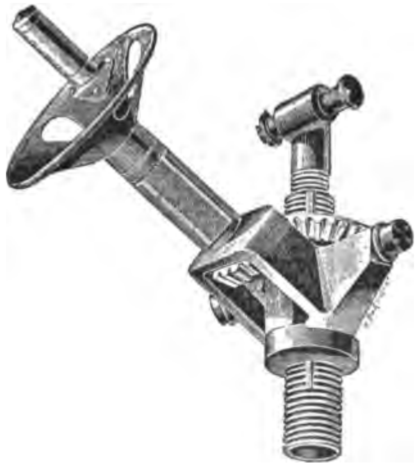


Fig. 5.

Pointing in elevation and in direction is accomplished by means of hand wheels placed immediatly under the hand of the gunner (figs. 4 and 5).

Carriage (fig. 6).—The carriage is of the rigid type, with a trail spade. The converging flasks are made of steel plate. The axle is hollow. The wheels have a diameter of 1.20 meters, which is less by 0.20 meter than those of the model 1873 carriage. The lowering of the axle gives the carriage more stability. The carriage has a box for the accessories which serves at the same time as a seat for the cannoneers. The recoil of the carriage is principally checked by rope brakes similar to the Lemoine brake and which serve also as a traveling brake. In cases where this brake is insufficient, and in all cases where rapid fire is employed, the folding trail spade is made use of. The right arm of this spade carries a chain which is connected when the spade is lowered, with a hook fixed to the right flask. This brake

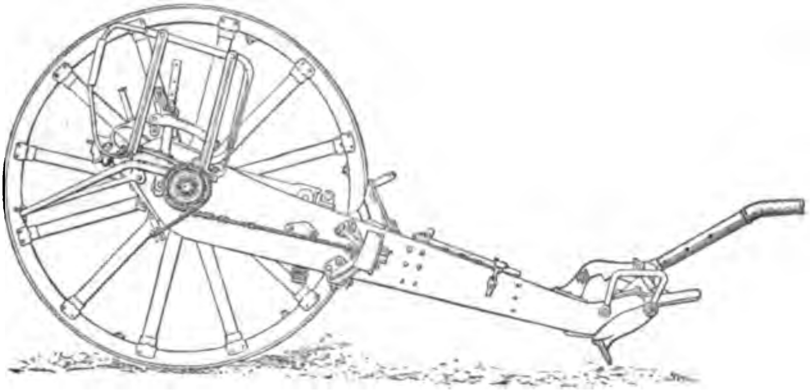


Fig. 6.

arrangement could be adopted only because of the feeble initial velocity of the projectile (less than 480 meters).

Ammunition.—The ammunition is composed of cartridges and projectiles not united, an arrangement which does not tend to increase the rapidity of fire. The service cartridge is composed of a brass case with flange, and with priming in the base. The charge is composed of 580 grams of a powder which has an external appearance resembling Ballistite or Cordite. This powder is less brittle than that formerly used because of the decrease of the dimensions of the powder chamber. The empty case is not ejected automatically after the discharge. It is thrown to the rear and seized by a cannoneer, who throws it over the left wheel of the carriage. The projectiles adopted were shrapnel and shell, andhave the same exterior form and sensibly the same length, about 4 calibers (in place of 2½ as formerly), and about the same weight, 6.800 kilograms. The shrapnel has a steel case and rear charge, and its bursting charge is a fine-grained powder. The balls, which are mixed with a smoke-producing composition, number 300 and have a total weight of 3 kilograms. Upon the case is screwed a head which receives the fuse, and which is thrown off at the moment of bursting.

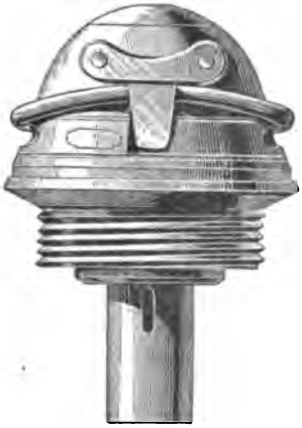


Fig. 7.

Fuse, Model 1896 (fig. 7).—The fuse is a double-action fuse and has a dial with two steps. It is graduated for ranges from

400 to 3,000 meters. The safety pin is removed before loading by means of a ring; and for transportation the ring is pressed down on the fuse in such a manner as to cap it.

Limber.—There is only one model of limber for the piece and caisson. The axle and wheels of the limber are similar to those of the carriage. The ammunition chests open to the rear by means of a door which lets down, forming a table. It is divided into three compartments. The two side compartments contain altogether 36 rounds, distributed by fours in ammunition baskets. The middle compartment is intended for accessories.

Total Ammunition Supply.—The total ammunition supply of a battery is 1,008 rounds, of which 216 are carried by the limbers of the piece and 792 by the nine caissons. This gives 168 rounds per piece. There were only 142½ rounds with the old material used.

Fire.—While allowing a rapidity of fire much greater, the maximum rapidity of fire allowed to a battery is 30 rounds per minute, that is, 5 rounds per gun, with the object of reducing as much as possible the expenditure of ammunition. The trajectory is much flatter than with the old model. At 2,000 meters the maximum ordinate, which was 48 meters formerly, is only 36 meters. It can be seen from the various figures given that the limits of efficiency of artillery fire admitted up to the present time have been increased for the new gun by a distance of from 600 to 1,000 meters.

Principal Dimensions, etc.—These dimensions, etc., are as follows:

Caliber of gun	millimeters	77
Length of gun	meters	2.70
Number of grooves		32
Diameter of carriage wheels	meters	1.20
Weight of piece unlimbered	kilograms	925
Weight of piece limbered	kilograms	1,670 to 1,700
Weight of shrapnel	kilograms	6.8
Length in calibers		4
Number of balls		300
Weight of charge in cartridge case	grams	580
Initial velocity	meters	465
Number of rounds per piece		168

A consideration of these figures allows us to affirm that the new piece is more efficient than the old heavy piece, while being lighter than the former German piece. The various parts of the projectile correspond practically to the weights and proportions indicated in the reports from the Krupp factory as being the limits which should not be exceeded.

NEW FIELD HOWITZERS.

Quite a number of German papers have recently reproduced the following note:

"It appears from numerous experiments that torpedo shells have not given good results when fired against objects placed behind cover. As a consequence, the idea has occured to return to the old howitzers, and a piece has been successfully constructed fulfilling all the desired conditions, and combining great power with remarkable accuracy. In the trials which are continued without interruption, perfect results have been obtained. It should be observed that the projectiles fired by this howitzer are provided with a perfect fuse, in that its effects are retarded. In other words, the shell provided by this arrangement and fired against houses, walls, or intrenchments, bursts only after passing partly through the object, thus producing the maximum effect. By reason of this our field artillery possesses an advanced position compared with that of other powers, and incontrovertibly occupies the first rank."

According to the "Jahrbücher für die deutsche Armee und Marine," this new piece has received the designation of "field howitzer, model 1898." It has been adopted for the armament of the group of three batteries of pieces with curved fire, which form part of the artillery of each army corps. Its caliber is 10.15 centimeters, and the weight of the projectile is about 16 kilograms. The various parts of this gun are similar in principle to those of the model 1896. The projectiles are shrapnel and explosive shell provided with double action fuses. The metallic cartridge not lending itself readily to the employment of different charges, a short case has been adopted provided with a flange and carrying the priming arrangements.

REORGANIZATION.

At the same time that it proceeded with the reconstruction of its material, Germany prepared a complete reorganization ot its field artillery. The tendencies which prevailed as regards this point can be summed up as follows:

1. Organization in time of peace ought to approximate as near as possible to that in time of war; hence the necessity of multiplying the regiments.

2. The permanent assignment of artillery to divisions is desirable in order to secure an intimate union between this arm and the infantry.

3. The horse batteries of the artillery corps, no longer having any reason for existence, should be abolished and the corps artillery should be divided among the divisions. The entrance into immediate action of all the artillery of the army corps of the first line would thus be facilitated and the artillery would be familiarized with the intricate formations of the infantry and the chiefs would be given the means of preparing themselves for the commands that they were to exercise.

ENGLAND.

STATUS OF THE QUESTION.—The minister of war is engaged in putting the field and horse artillery on a par with that of the continental powers. The question is of great importance. since in England various models have been adopted for the last twenty years without completely abolishing the pieces of former model. The last type adopted in 1897, is of 3 inches in caliber (76.2 millimeters). The gun is of steel, weighs 360 kilograms, and is composed of an interior tube and of a jacket carrying the trunnions. It has a screw breech mechanism which is supported in firing by the jacket. The screw and obturating mechanism belong to the De Bange system. Model II carriage has as its characteristic feature a small carriage which pivots around the axle and is supported in the rear by the pointing screw. The recoil of the gun, limited by a hydraulic brake, takes place at first by a displacement of about $\frac{1}{10}$ meter of the piece with relation to this small carriage, then by a movement of the carriage as a whole, which is reduced to almost nothing by the action of an apparatus for braking the wheels. The whole of this mechanism is arranged in such a way that the carriage can be given the necessary displacements for pointing in direction without taking the spade out of the ground. The rapidity of fire is 5 rounds per minute. The hydraulic brake is connected on the one hand with the small carriage and on the other hand with the breech. The path of the piston is from 10 to 16 centimeters. In front of the brake are coiled the spiral springs, which bring the piece back to the firing position. Field howitzers have been recently adopted which are 5 inches or 127 millimeters in caliber, and similar to our 120 millimeter short guns. This piece is supported by a cradle which carries on each side a hydraulic brake cylinder and two recuperator spring cylinders. The recoil is thus reduced to 0.13 meter. It ought to be remarked here that the English artillery construct their guns of steel wire, although these guns are still only in the experimental stage with other powers. It is known that the process consists in wrapping around a central tube steel wire which reenforces it like hoops and allows it to support much greater efforts than with the ordinary method of hooping.

STUDIES.—Some studies have been made with a view to the adoption of a rapid-fire artillery material. A complete battery of 12-pounder guns has been ordered from the Vickers, Sons & Maxim Company for the horse artillery. This new piece with its limber provides for 40 rounds and weighs 1,520 kilograms. The rapidity of fire is 9 rounds a minute and the carriage is very strong. The screw breech mechanism is provided with the De Bange obturator, is very short, and light, and arranged in such a manner as to open with a single movement. It has a percussion firing mechanism. The energy of recoil is absorbed by a hydraulic brake in conjunction with a spring whose office is to bring the piece back to its original position. The Government has also invited Woolwich Arsenal, as well as Armstrong, Whitworth & Co., and the Vickers, Sons & Maxim Company each to present a type of rapid-fire field gun firing a projectile of 15 pounds in weight. According to the "Daily Chronicle" of the 31st of March, 1900, the results of these numerous tests made with these various pieces have ended in the adoption of the Vickers, Sons & Maxim material, that is to say, a 15-pounder gun for the mounted artillery and a 12-pounder gun for the horse artillery. These guns are in one sense only Maxim automatic guns, perfected. According to other authorities there will be a system of twenty pieces of the material cited above, ranging from 37 millimeters to 304.8 millimeters in caliber. The general construction of these pieces will be as follows: Hooped with steel wire; De Bange obturator; breech mechanism of the type invented by the Swedish engineer, Axel Welin, which is distinguished by the arrangement of the threaded sectors which in place of alternating with the smooth sectors are in juxtaposition, their radii increasing successively by the height of the thread, and of the twelve sectors it is sufficient to have only one smooth one so that to withdraw the screw it is necessary to give it but one-twelfth of a turn. The supporting surface is therefore increased from one-half to eleven-twelfths, which allows a corresponding diminution in the length of the screw. The pointing is effected with a Scott telescopic sight. The carriage which returns automatically to battery has a large spade fixed at the rear end of a hydraulic brake which extends under the flask. Around the piston of the brake cylinder is coiled a helical spring which acts as a recuperator and brings the piece back to its original position. The spade is connected to the carriage with two chains slightly slack which allows the piece to be given slight changes in direction without changing the spade from its place. For the field piece of 76.2 millimeters in caliber the weight of the projectile is 5.675 kilograms; of the charge of cordite, 454 grams; of the gun, 290 kilograms; of the piece and limber loaded with 40 rounds, 1,220 kilograms. The initial velocity is 518 meters. A communication made to the House of Commons indicates that the construction of these new batteries has been commenced. The secret experiments with explosive shell have been very well guarded, but it is known that the explosive used in these explosive shells is Lyddite, composed principally of picric acid.

AUSTRIA-HUNGARY.

Changes Made.—While expecting to proceed with a complete reconstruction of its field material the Austrian artillery proceeded to modify its material in actual use in such a way as to put it in condition to maintain the struggle under favorable conditions with rapid-fire artillery. Thus, the cannon of 9 centimeters, model of 1875, was modified at small expense from time to time to permit of a considerable increase in the rapidity of fire. All these pieces thus modified gave very satisfactory results during the test of 1898. The changes made had for their object, on the one hand, increasing decidedly the rapidity of fire, and, on the other hand, of rendering easier the service of the piece, while preventing premature discharges. These various modifications relate to the following points:

1. The adoption of a spur brake designed to diminish the recoil, which from 2 or 3 meters, is reduced to $\frac{4}{10}$ of a meter or $\frac{8}{10}$ of a meter with this apparatus. The latter consists of a spur or trail spade, surmounted by an arm united to the upper plate of the flask. Before firing the spade is more or less sunk in the ground, according to the character of the soil. At the moment of fire the carriage recoils and the spade pivots around its edge and ends by burying itself in the soil. From the middle of the frame of the spur a very strong horizontal rod extends to the front, carrying a series of Belleville springs, and at the front of these springs is fitted an annular metallic buffer, which is fixed to the carriage. During the recoil the trail spade is dragged until the friction of the soil has checked the movement of the carriage, that is to say from $\frac{8}{10}$ to 1 meter. The extension of the Belleville springs has a tendency then to bring the piece

forward to about eight-tenths of its original porition. Firing is thus rendered more rapid, so that 6 shots a minute can be very readily fired. The total weight of the brake is 22 kilograms.

2. The addition of a vent shield intended to stop the vent and prevent the primer being put in place before the breech is completety closed in such a way as to avoid accidents during rapid firing.

3. The use of an obturator of the model of 1896, of the same strength but of less dimensions than the old one. This obturator has for its object the insuring of complete obturation with the smokeless powder recently adopted.

4. Modification of the sight, with a view of rendering needless all change of the slide of the latter during shrapnel firing.

5. Adoption of new shrapnel, model of 1896/96 a, which, with the same weight (about 6.9 instead of 6.52 kilograms), contains 250 hardened lead balls weighing 13 grams, and a powder charge of 120 grams, while the old material comprised only 152 balls of 10 grams weight each and a charge of powder of 90 grams. This new shrapnel is of much greater efficiency than the old shrapnel, and as its bursting charge is greater its point of burst is more readily observed.

6. A special arrangement assuring automatic uncapping of the shrapnel and automatic removal of the safety pin, an improvement which permits of a certain saving of time.

7. The adoption of the new shrapnel has had for its consequence the abolition of case shot.

8. To facilitate the operation of setting the fuse, which requires on the part of the cannoneer close attention and calmness, an automatic fuse wrench has been adopted. The accuracy of this fuse setting and the rapidity and uniformity of the operations are thus greatly increased.

9. A primer pouch of the model of 1896 has been adopted in which the primers are so kept that they can be naturally and conveniently removed by the hand of the cannoneer. This is a detail which permits of great rapidity of fire, as it allows the cannoneer charged with this service to rapidly introduce the primer and fire immediately after the loading.

STUDIES FOR NEW MATERIAL.—The technical military committee is at present experimenting with a new field artillery material which on the authority of the "Armeeblatt," comprises two kinds of steel guns; a direct-fire gun, that is, a rapid-fire piece of 7 centimeters, and a gun for curved fire, a breech-loading field howitzer of 12 centimeters caliber. The "Austrian Journal" adds that the experiments being made by this technical committee with this new material are on the point of being finished. The difficulty which, up to the present time, has delayed the final report is in the construction of the carriage. It is desired that this latter shall fulfill the wished-for conditions of giving the new pieces great lightness and mobility in conjunction with the necessary rapidity of fire. This lightness and mobility are recognized as indispensable for rapid-fire guns, so that they shall be able at the desired moment to obtain a superiority over small-caliber repeating rifles. On the other hand, a certain amount of time will elapse before the minister of war will obtain the necessary credits for the construction of this new material and before the troops are provided with it. Under these conditions it is probable that the modified gun will not be replaced so soon. It is furthermore in a way of competing seriously with other rapid-fire guns for its rapidity of fire appears to be sufficient. There will be reasons, nevertheless, from this point of view for making the necessary arrangements to increase the ammunition supply.

SPAIN.

STUDIES MADE.—Financial considerations have not permitted the Spanish artillery to enter as actively into the work of experiments upon rapid fire guns as its reputation demanded and as it desired, but has not ceased to keep informed regarding guns of the different models brought out by the different manufacturers, and its officers have been able to attentively follow experiments made in this direction. These officers have drawn up a very interesting report of their mission. As a consequence, in the month of August, 1896, the director general of the Spanish artillery invited the experimental committee at Madrid to submit to it propositions for the various types of rapid-fire guns that it would be desirable to experiment with. According to the "Revue D'Artillerie," September, 1897, the commission summed up its conclusions as follows:

1. The rapid-fire gun has aquired at the present time a power which renders it suitable for field service.

2. Regarding the condition of the Spanish field artillery material, there is urgency in making experiments for the adoption of new material.

3. No new material should be adopted which does not allow pointing after each round. As the necessary time for this operation depends not alone upon the mechanism for pointing,

but also upon the extent of the recoil, the practical abolition of this latter is of primary importance.

4. The commission admits of a caliber of 75 millimeters with a projectile weighing 6½ kilograms.

5. A metallic cartridge ought to be adopted, and if the arrangements in the ammunition chest are suitable the projectile and charge ought to be united.

6. A howitzer of 12 centimeters ought to be experimented with, because of the necessity for curved fire in the field.

7. The new field material of Colonel Sotomayer and the mountain material of Lieutenant Colonel Ordoñez, should be included in the test of others. The different model field guns noted as having been experimented with are the Krupp, Maxim-Nordenfelt, and Saint Chamond, all three of 75 millimeters caliber. The models of the mountain guns are the same. The Krupp has a strong carriage which is not very delicate, but the piece is not so heavy as in other types. The Saint Chamond is the most powerful, but the mechanism is more complex. The Maxim has medium power and a good breech mechanism. It appears moreover from information derived from the "Memorial de l'Artillerie" that the Saint Chamond type came out ahead, but as there seemed to be a desire to give the preference to the Krupp, experiments were made with six models of carriage by this company without obtaining, nevertheless, results as satisfactory as were obtained with the model of carriage presented by the company in 1895, without any modifications made in it.

FRANCE.

General Information.—It is known that in France the artillery conceals with jealous care all its newly adopted models, both of small arms and cannon. We have seen that in Germany, on the contrary, an effort is made to broadly publish everything that is admitted officially, for it is a principle there, that it is not sufficient merely to possess a perfect material, but, besides, that it is necessary to get all the advantage possible out of it. Now, to arrive at this result, the Germans are of the opinion that not only the characteristics and the workings of a new armament ought to be well known by those who are called upon to use it, but, besides, all in the army ought to know, since they have an interest in keeping posted on the progress of other arms in order that they shall know what confidence to place in them, and the best way of utilizing them. It is known that a new field material has been adopted and that more or less secretly a number of pieces sufficient to arm all our batteries has been constructed, but a large number of our officers do not know anything about this new material, and without intending to criticise this mystery, which perhaps has a reason for existence, we regret that we are not able to prove to the German minister of war that he is mistaken when he says in Parliament that the new German field gun is very superior to ours. Although affirmation may not be a proof, it nevertheless has a certain value and may have a certain amount of influence when it comes from high authority and when it is not denied by conclusive arguments. The prevailing opinion in the German service is that our new field gun has neither the simplicity, the strength, nor possibly the power of the German gun. We do not know from what source this presumptive conviction is derived, for we are persuaded on the contrary that our new gun is without a peer, and that it would be very easy to demonstrate it if it was adjudged necessary. However that may be, we will take good care not to commit any indiscretion regarding our new material, and we will limit ourselves here to giving the information which has already been given in various publications renarding it.

First of all, the new gun is of the Deport system, is made of nickel steel and is 75 millimeters in caliber. There is no special model for the batteries of artillery attached to cavalry divisions.

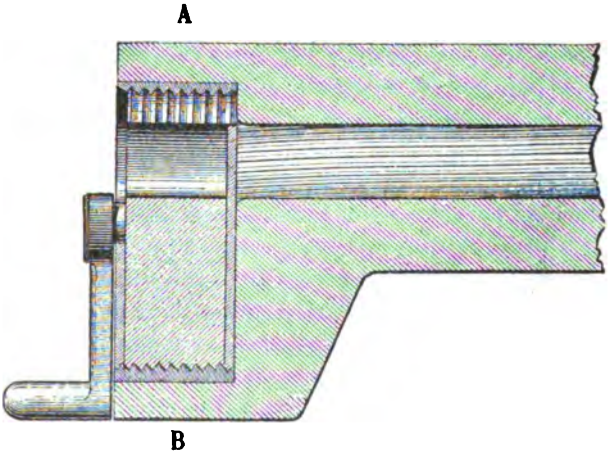
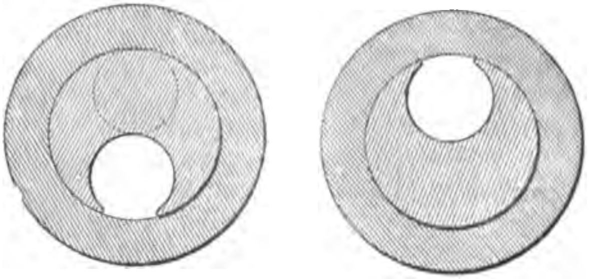


Fig. 8.

In fact, the new gun, not weighing any more than the old 80-millimeter gun, and having a much greater power, very nearly answers all requirements. There is a decided advantage from this point of view of facility of ammunition supply as the projectiles will be the same for the mounted artillery. At present an effort is being made to replace the 80-millimeter material now in use for the mountain artillery. Experiments are being made with this end in view, with a rapid-fire gun of 75 millimeters intended for the Alpine batteries, by a corps stationed in Algeria and Tunis, as well as by the marine troops on duty in the colonies (fig. 8). The breech mechanism is of the Nordenfelt system. This mechanism is a marvel of simplicity and satisfactory in its working. This is the principle: It consists of a screw whose section perpendicular to the axis is of the form of a crescent (see fig. 9). The axis of the screw does not coincide with that of the piece; hence the motion is eccentric and a simple rotation of 180° closes or opens the bore of the piece. Figure 8 gives a section of the piece. Figure 9 represents a section of the breech along *A B* in its two positions. It is known that the German artillery continues to use the breech wedge, which although offering greater security, has the disadvantage of being more complicated in its action. The model of carriage adopted has some very notable improvements over the 120 short, which will be discussed later on. The carriage for the new gun has a hydropneumatic brake supplemented by a spring. The elasticity of the air and the spring causes the return to battery. As soon as the trail spade is anchored in the ground the piece remains fixed. Two cannoneers seated on the piece are sufficient for its service. They are protected by a shield made of steel plate. The gun is carried by a cradle which is moveable around a vertical axis. It is capable of a lateral displacement, which permits not only the correction of pointing in direction without touching the trail, but further, during rapid fire with shrapnel, of making slight changes in pointing in such a way as to "sweep the ground" with the fire of a single piece, thus covering with its projectiles a space of two hectares. The The caisson is placed alongside of the piece. The cannoneer at



Section along A B.

Breech closed. Breech open.

Fig. 9.

the caisson who supplies ammunition, charged also with graduating the fuses, is placed during fire under cover of the caisson which is provided with a steel plate on the face turned toward the enemy. The projectiles are, first, melinite shell which is employed against inanimate objects, houses walls, etc., and, second, a steel shrapnel with rear charge, containing 250 balls according to some authorities and 300 according to others. The shrapnel makes a dense cloud of smoke which prevents the enemy from seeing and aiming. The piece has been fired 22 rounds a minute (according to the Russian General Englehart) and the initial velocity of the projectile is about 480 meters. The loading is by metallic cartridges containing the projectile, powder charge, and priming composition. All that is necessary to do is insert the cartridge in the gun and close the breech and the gun is ready to fire. The metallic case is expelled automatically when the breech is opened. Once more I regret that the prohibition against giving any official information about our new gun does not allow us to present but a very vague idea of it. We would be especially grieved if it should be inferred from this superficial and general statement that our new material is inferior to that of foreign powers. We cannot repeat too often, on the contrary, that our new field artillery material is superior in all respects to that of other powers, and that it is not our fault if we cannot prove it.

CANNON 120 SHORT.—For curved fire, that is to say, to reach troops behind intrenchments, the direct-fire piece with a flat trajectory can not be employed. Moreover, the ordinary field piece of 75 millimeters does not always have the necessary power to destroy obstacles such as houses, intrenchments, etc., which are an obstacle to the advance of troops. For this reason a rapid-fire gun, short, of 120-millimeter caliber has been adopted, which can fire under high angles very powerful projectiles which search all the depressions of the ground and burst behind all masses which would afford shelter to the enemy and which act like torpedo shell against resisting objects. This piece is mobile enough to cross fields and has rapid-fire because of the suppression of the recoil as stated. The cannon, properly speaking, is of steel with a jacket screwed on the middle of the tube and supported against shoulders made in the rear part of the latter. The breech mechanism comprises a breech screw which serves to close the breech, and a carrier ring which serves to support and direct the screw during the opening or closing of the breech, and an obturator carried by the screw, which prevents the escape of gas to the rear. A sleeve with trunnions on it, made of bronze, envelopes the gun in its middle portion. It is connected to the gun by means of a hydropneumatic brake and to the carriage by means of the trunnions. The carriage is composed of two principal parts. First, the main carriage carrying the axle, and thus forming, so to speak, a platform. A spade is riveted to the trail of this carriage which has for its object the prevention of displacement of the gun carriage and of checking the recoil of the latter by the effort of the pressure which the action of the brake brings on the trail. Second, a small carriage which rests on the main carriage and has a circular movement. The hydropneumatic brake almost completely suppresses the recoil of the piece. It is composed of a steel cylinder containing oil connected with the gun by the lug of the breech ring, and of a reservoir of air or recuperator made of bronze screwed into the lug of the trunnion sleeve. When the piece is fired the gun recoils in the sleeve, dragging with it the cylinder. The brake is put into action in such a manner that this movement brings a pressure to bear on the liquid in the cylinder and forces it to escape by raising a loaded valve and compressing the air in the recuperator, which limits the recoil at the maximum to 0.475 meter. At the end of the recoil the compressed air exercises a push on the liquid, forcing it to return through the small orifices in the cylinder, and to bring the latter forward and the gun into battery. The mechanism for pointing in direction allows the small carriage to be turned on the main carriage. The pointing is accomplished, moreover, very rapidly, because the main carriage is not moved and the piece is always approximately pointed at the moment of its return to battery. The 120-millimeter cannon, short, fires a special shrapnel (fig. 10), model of 1891, which has a length of about four calibers, is made of steel, and has a large interior space filled with melinite. The explosion of the shell is produced by means of a bronze fuse screwed into the eye of the projectile or case. The charge of balls is

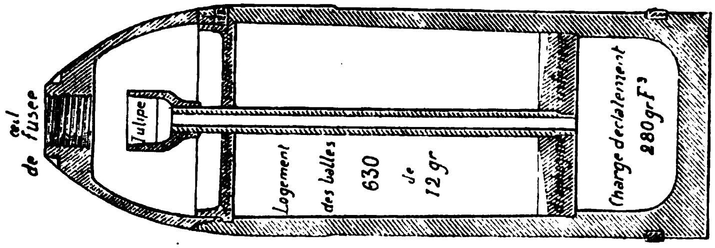

œil de fusée
Tulipe
Logement des balles 630 de 12 gr
Charge d'éclatement 280 gr F³

Fig 10.

about 630 in number, of hardened lead, weighing 12 grams each. These balls are embedded in resin and covered with a mixture of resin and of yellow wax. The shell is painted yellow and weighs about 20.35 kilograms. The long shells are capable of producing considerable effect by shock and explosion against the obstacles. In fact this projectile is a double diaphragm projectile, that is, an "obus canon," which means that it has a rear charge which is not deformed in firing, it acts at the moment of bursting like a small cannon which projects its contents to the front. The cartridge is composed of a charge of smokeless powder B. C. and priming powder C., intended to facilitate the burning of the smokeless powder. This charge is inclosed in a bag of cartridge cloth of silk waste which burns in the bore of the gun without leaving any traces.

Numerical data of the 120-millimeter short gun:

Diameter of bore	millimeters	120
Total length of gun	meters	1.70
Number of grooves		36
Total weight of gun	kilograms	690
Weight of gun and carriage	kilograms	1,475
Weight of limber	kilograms	800
Weight of piece limbered up	kilograms	2,365
Weight of caisson	kilograms	2,360
Weight of the projectile	kilograms	20.35
Number of balls		630

(To be Concluded.)

A DISCUSSION OF THE ERRORS OF CYLINDRO-OGIVAL PROJECTILES.

Translated from the French of General Douny in *Revue de l'Armée Belge* of January-February, 1900,

By J. M. Williams, 1st Lieut., Artillery Corps.

(Continued).

Determination of the Coefficient $C = \frac{g \Delta k}{3 v^2}$. The mean variation, Δk, is here the only unknown term. It does not seem possible to determine directly, otherwise than by the method of differences, its entire value—that is to say, the variation, Δk, really due to variations in tangential resistance combined with the Δk that is intended to account for the variation in vertical deflection (see p. 6, discussion following equation (4)). But as this last variation is surely of very little importance, we shall at first neglect it, and shall seek only the mean variation of k due to variation in tangential resistance.

This last variation can be calculated by two methods that are based on the use of the clepsydra; it is well known that this ingenious instrument gives the total time of flight within a thousandth of a second.

From the equation giving this time,

$$t = \frac{x}{v \cos \varphi}\left(1 + \frac{1}{2} kx - \frac{1}{6} k^2 x^2\right)$$

remembering that k is connected with the velocity by the relation

$$k = \frac{A r^2}{m} v^2, \ A \text{ being a constant,}$$

we shall, by a process similar to the one employed in finding the variations of the ordinate, easily deduce:

$$(\Delta t)_{\varphi} = \frac{x \tan \varphi \Delta \varphi}{v \cos \varphi}\left(1 + \frac{1}{2} kx - \frac{1}{6} k^2 x^2\right) = t(\tan \varphi \Delta \varphi);$$

$$(\Delta t)_{v} = \frac{x}{v^2 \cos \varphi}\left(1 - \frac{1}{2} kx + \frac{1}{2} k^2 x^2\right) \Delta v;$$

$$(\Delta t)_{k} = \frac{x^2}{2 v \cos \varphi}\left(1 - \frac{2}{3} kx\right) \Delta k;$$

$(\Delta t)_{\varphi}$, $(\Delta t)_{v}$, and $(\Delta t)_{k}$ representing respectively the variation caused in the total time of flight by the mean variation in angle of departure, in initial velocity, and in atmospheric resistance; their total resultant, Δt, will be:

$$\overline{\Delta t}^2 = (\Delta t)^2_\varphi + (\Delta t)^2_v + (\Delta t)^2_k .$$

A priori it seems evident that the variation $(\Delta t)_\varphi$ can be completely ignored, the chief advantage of the clepsydra consisting exactly in giving results that are independent of the variations in the angle of departure. And in fact if, for the 8^c gun, we seek the variation $(\Delta t)_\varphi$ for a range of 2000 metres, using the value of $\Delta\varphi$ found above, we get:

$$(\Delta t)_\varphi = 0^s.0003.$$

The clepsydra shows a mean total variation of

$$\Delta t = 0^s.034,$$

which is a hundred times greater than the value of $(\Delta t)_\varphi$, and consequently cannot be affected by it.

The equation giving the variation in flight reduces, then, to

$$\Delta t^2 = (\Delta t)^2_v + (\Delta t)^2_k .$$

1st Method. Let us suppose that for each shot of several series of shots we have observed the initial velocity by means of the chronograph, and the time of flight by means of the clepsydra; for each series we shall determine the mean initial velocity and its mean variation, the time of flight and its mean variation: the preceding equation, in which Δt and $(\Delta t)_v$ will then be known, will give $(\Delta t)_k$ and consequently Δk.

If the mean variation in initial velocity were known in advance, it would be unnecessary to make use of the chronograph.

We have not data that permit us to apply this method to the 8 and 9 centimeter guns; but appendix II., taken from the already mentioned work by General Le Boulengé, gives the means of making the calculation for the 12 steel gun. The initial velocities were not taken; but the firing having been done with the type powder, the mean variation in velocity has been deduced from other experiments with the same gun (appendix II.).

The data for the calculation are as follows:

$v = 353$ meters.
$k = 0.000247$ (deduced from the mean time of flight for 1000 meters).*

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* The value of k is slightly greater than that which would be deduced from the value of this constant for the 9^e shell; but we know that for small ranges k is to be slightly increased. (See on this subject our discussion of the trajectory of oblong projectiles.)

$\Delta v = 1^m.36.$
$\Delta t = 0^s.01245.$

From which we deduce

$\Delta t = 0^s.009897, \qquad \Delta k = 0.000,006,23.$

The ratio $\frac{\Delta k}{k}$, that is to say the ratio between the mean variation in k and that coefficient itself, is thus 0.025.

It is not possible to make use of the practice made with the same piece at 600 and at 400 meters. Indeed, if we examine the formulas giving $(\Delta t)_v$ and $(\Delta t)_k$, we shall see that the variations in time they represent are nearly proportional, in the case of the first, to the range; and in the case of the second, to the square of the range. The shorter the range, then, the greater will be $(\Delta t)_v$ in comparison with $(\Delta t)_k$; now even at 1000 meters, as may be seen by comparing the values found above for $(\Delta t)_v$ and $(\Delta t)_k$, the total variation is not large enough, relatively to its known component, for the calculation to give a very accurate result; moreover, the clepsydra's error, $0^s.001$, is not negligible for short ranges.

2nd Method. If we do not know the mean variation in initial velocity, and if we have only data from too small a number of shots to determine it, the calculation is still possible provided the initial velocity has been recorded for each trajectory.

Let us suppose that, as in the case presented by the data of appendix I. relative to the 8^c gun, we have fired at different ranges series of three shots each; and, neglecting the errors of the chronograph, let us assume that all the initial velocities have been perfectly recorded.

For a series of three shots we shall calculate the mean initial velocity and the mean time of flight; if, by reason of an initial velocity smaller than the mean, the first projectile ought to have reached the target with a retardation determined by calculation to be $0^s.01$, while the retardation recorded by the clepsydra is $0^s.03$, the difference, $0^s.02$, will be due to the increase in the resistance of the air, and it will be possible to determine the corresponding Δk. By proceeding in the same way for the other two shots of the series and taking the mean of the results, we shall obtain the mean Δk of the series.

The other series will give, in turn, other mean values for Δk; the mean of these mean values will correspond to the mean range at which the shots have been fired,* 1500 meters, for example, if the shots have been fired at ranges between 1000 and 2000 meters; and, this time, it will be the result of a sufficiently large number of shots for the law of the composition of errors, which is inapplicable to one series of three shots, to be made use of in correcting the errors of the chronograph. We shall then seek, for a range of 1500 meters: (1) the variation in time corresponding to the mean Δk; (2) the variation in time corresponding to the chronograph's mean error in recording the velocity; the square root of the difference of the squares of these two times will be the mean variation in time, rid of the inaccuracies of the recording of the velocities: we shall from it deduce the time mean Δk.

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* We have seen above that Δk is nearly independent of that range.

It must be observed, however, that the influence of the chronograph's error is relatively greater at 1000 meters than at 2000 meters; in order that the correction made at 1500 meters be sufficiently accurate, then, it is necessary that, even at 1000 meters, the influence of the instrument's error be of little importance.

We have applied this method to the data of appendix I. relative to the 8^c gun, since from them we do not know the mean variation in velocity, different powders having been used.

The shots that we may use* give for the ratio $\frac{\Delta k}{k}$

for 1,000	meters	0.009
for 1,200	"	0.022
for 1,400	"	0.024
for 1,600	"	0.018
for 2,000	"	0.034

a mean, for 1500 meters, of $\frac{\Delta k}{k} = 0.021$.

This figure must then be freed of the error due to the chronograph. When the velocities are about 380^m the instrument makes in them a mean error that is, according to the note at the end of this discussion, $0^m.39$ when the targets are separated by 50 meters, and that increases inversely with the distance between the targets.

In the experiments in question the distance between targets was only 37 meters, so that the mean instrumental error is

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* The shots fired on Oct. 29, at 1400 m., and on Nov. 4, at 1800 m., being isolated could not be used: it also was necessary to discard the two shots of Nov. 6, an error being in the data: indeed, the initial velocity of the second shot at 1800 meters ought to be 378.02, instead of 379.08 in order to agree with the time of flight between the targets as given in General Le Boulengé's work.

$0^m.39 \times \frac{50}{37} = 0^m.52$, giving for 1500 meters a variation in time of $0^s.0045$; by calculating for the same range the variation in time corresponding to $\Delta k = 0.21$, correcting this variation by means of the chronograph's, and then finding the corresponding correct value of Δk, we finally get

$$\frac{\Delta k}{k} = 0.019.$$

In calculating this mean we have not used the data of practice at less than 1000 meters, the chronograph's error reaching even at this range half the total error.

The ratio, $\frac{\Delta k}{k} = 0.019$, obtained for the 8^c gun at a range of 1500 meters, is not founded upon a sufficient number of shots; but we may combine it with the ratio deduced from experiments made at 1000 meters with the 12^c gun, which ratio is

$$\frac{\Delta k}{k} = 0.025.$$

It is to be remarked that, when projectiles of the same system but of different caliber have the same mean velocity over their trajectories, all the causes of deflection at all important operate in such a way as to give for each of the calibers the same value to the ratio $\frac{\Delta k}{k}$.

This identity is at once evident in the case of the variations in the density of the air. In the case of the wind also, it is justified by the calculations set forth above, when the mean velocity is the same as that in the experiments with which we are concerned (319 meters for the 12^c shell between ranges of 0 and 1000 meters, 310 meters for the 8^c shell between 0 and 1500 meters). Finally, if the accidental variations in the inclination of the axis of the projectile to the tangent to the trajectory have some influence on k, as it is a question of projectiles similar in shape and system, the coefficient of the resistance will likewise be influenced in the same proportion.

We are all the more justified in combining the results obtained with the 8^c and 12^c shells since the ratios that they furnish are pretty close in value; their mean*

$$\frac{\Delta k}{k} = 0.022$$

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* The remaining velocity at 1500 meters is 269 m. for the 8^c shell, and 262 m. for the 9^c shell.

differs then so little from 0.019, for the 8^c shell, or from 0.025, for the 12^c shell that it is only at very long ranges, at which the error due to the resistance of the air becomes preponderant, that the total error is appreciably changed accordingly as we adopt one of the extreme figures or their mean.

The above mean has been gotten without taking into account the number of shots, because, if that number has been greater in the case of the 12^c shell, the number of separate target practices has been greater in the case of the 8^c shell: there is thus true compensation in the values of the experiments. But for this consideration the mean value of the desired ratio would have had to be fixed at 0.023.

The mean $\frac{\Delta k}{k} = 0.022$ corresponding to 38 shots fired during a large number of *different target practices, each of long duration, and consequently during very varied atmospheric conditions,* is thus determined under favorable conditions—all the more favorable since, thanks to the employment of the clepsydra, there is the guaranty of accuracy peculiar to direct measurements, the resulting ratio being uncontaminated by variations in angle of departure or in vertical deflection.

The clepsydra was not used in the case of the 9^c shell's trajectory; but the preceding considerations applying to its trajectory at 3000 meters, we shall use the same ratio, 0.022, for the calculation of the errors of this projectile.

It is important to observe that, through the way in which we have calculated the coefficients of the lines representing the errors caused by each of the groups of causes, we have from no group omitted any *cause*, however small: only the *variations* in the vertical deflection have been neglected.

The total error calculated conformably to equation (1) will, then, include all the variations that affect φ, v, and k, excepting the variations in vertical deflection.

The following table gives for every 500 meters the calculated* partial and total errors.

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* The calculations for this table have been made by Lieutenant Slingeneyer de Goswein, who has been kind enough to undertake also the preparation of the plates that accompany this article.

RANGES (meters.)	MEAN VERTICAL ERROR CAUSED BY THE VARIATION IN						TOTAL VERTICAL ERROR.	
	Angle of Departure.		Initial Velocity.		Resistance of the Air.			
	8^c Gun.	9^c Gun.	8^c Gun.	9^c Gun.	8^c Gun.	9^c Gun.	8^c Gun.	9^c Gun.
	m.	m.	m.	m.	m.	m.	m.	m.
500	0.250	0.290	0.051	0.0587	0.0219	0.019	0.256	0.296
1000	0.500	0.580	0.204	0.235	0.175	0.150	0.567	0.64
1500	0.750	0.870	0.460	0.531	0.594	0.508	1.061	1.14
2000	1.000	1.160	0.822	0.950	1.416	1.21	1.918	1.93
2500	1.250	1.450	1.295	1.497	2.83	2.39	3.354	3.17
3000	1.500	1.740	1.893	2.184	4.88	4.18	5.443	5.02

Plate I. (in which the ranges, used as abscissas, are reduced to a scale of 1/20000, and the errors, used as ordinates, to a scale of 1/20) enables us to observe the rate of increase of the partial errors and of the total error. Instead of calculating the latter, it suffices to determine it graphically by the construction of two right-angled triangles.

COMPARISON OF THE ERRORS DETERMINED BY CALCULATION WITH THOSE DERIVED FROM EXPERIENCE.

The results of all practice in which we have been able to determine the mean error, are set forth in Appendix IV.

It is necessary to state that many perturbing causes might have produced or exaggerated the irregularities that are observed in the rate of increase of the experimental error :

1. In some firings, small in number however, the calculation of the means had been departed from, the shots being considered abnormal, and it has been impossible for us to reintroduce them.

2. The firings collected in the appendix have extended over nearly fifteen years. The mounts might, therefore, have been more strained in the later firings.

3. At the ranges for which the number of shots is small the firing has been done by a small number of pieces ; the results in such circumstances do not pertain to a mean piece.

4. Lastly and particularly, the duration of the practice, more often 4 to 5 hours, has been variable ; and some practices have taken place during chosen weather.

In order to give an idea of the differences that have been possible, as well from those causes as from ordinary dispersion, we set forth below in detail the means gotten at 1400 meters with the 8^c gun.

In 1867, 48 shots gave a mean error of $1^m.30$
In 1870, 120 " " " " $1^m.11$
In 1871, 312 " " " " $0^m.75$
In 1876, 900 " " " " $1^m.026$

General mean: $0^m.96$

Anomalies are important, then.

The experimental mean errors have been shown on the plates giving the theoretical errors; each of the points is accompanied by the number of shots that determined it, that is to say is accompanied by its weight.

An inspection of the plates shows that the agreement between theory and practice is absolutely satisfactory, and that it would be almost impossible to trace empirically a regular curve that would, better than the theoretical curve, take into account the experimental errors and their weights.

The value of Δk that we have used in calculating the errors caused by the variations in atmospheric resistance having been based upon only a comparatively limited number of clepsydra observations, we have thought we ought to determine it again, by the method of differences, making use of the results of all the practices collected above.

To this end, the mean total error for a given range being known experimentally, and the mean variation in angle of departure as well as the mean variation due to variations in velocity having been determined directly, the equation of the curve of errors would enable us to calculate the third component of the total error, and consequently the mean value of Δk that produces it. But the operations being rather long, it is preferable to have recourse to a graphic method that is quite sufficient here. Proceeding in the order of constructions detailed above, we shall easily subtract from the error gotten experimentally its first two components, and the third will thus be obtained by subtraction. If it is found to be 1^m 30, for example, and if the calculation based on a value of 0.022 for $\frac{\Delta k}{k}$ fixes it, on the contrary, at $1^m.10$, the ratio $\frac{\Delta k}{k}$ deduced from practice will be $0.022 \times \frac{1.3}{1.1}$ since Δk, according to the formulas is proportional to the errors that it produces at the target.

The method of subtraction is evidently indirect, and it has the very serious inconvenience of concentrating in the single term Δk all the constant perturbing effects, all the anomalous disturbances that have taken place in Δk, Δv, and $\Delta \varphi$ and could have disturbed the agreement of the results; but it presents the advantage of being based upon several thousands of shots.

Unfortunately, the greater number of those shots have been fired at moderate ranges, for which the error produced by Δk is far from being preponderant; therefore, if we wish to remain within the limits fixed by the second corollary to the law of the composition of errors, we must confine ourselves to the data furnished by shots at ranges above 1600 meters for the 8^c gun, and above 1800 meters for the 9^c gun.

Ranges.	8^c Gun.		9^c Gun.	
	Number of shots.	$\frac{\Delta k}{k}$	Number of shots.	$\frac{\Delta k}{k}$
1400	1380	0.024	1140	0.020
1500	320	0.026	144	0.009
1600	1306	0.027	1176	0.017
1800	490	0.028	670	0.027
2000*	94	0.022	111	0.022
2200*	82	0.022	40	0.022
3000*	66	0.020	65	0.011
Mean		0.025		0.020

This table suggests several remarks.

1. The values of $\frac{\Delta k}{k}$ are much more regular for the 8^c gun, because the errors due to the resistance of the air are of greater relative importance: the method of subtraction gives, therefore, more accurate results.

2. At the long ranges, the only ones on which we may rely with certainty, the mean is nearly the same for the two guns.

3. The greater number of the practices that have furnished data for the calculations, have lasted 4 to 5 hours. The values of $\frac{\Delta k}{k}$ must for this reason be much too large.

4. The mean value between 0.025 and 0.020, corresponding to the two guns, approximates very closely to the value lying between 0.022 and 0.023 found by means of the clepsydra, although in the latter value the variation of the vertical deflection was neglected.

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* Final practice of shorter duration, and perhaps in selected weather.

The agreement between theory and the practical results would justify, if necessary, the following principles laid down in the course of this work:

(*a*) The angular variations, $\varDelta\varphi$, is almost independent of the angle of elevation φ; that is to say, of the range.

(*b*) The variation in the resistance of the air can be calculated in a sufficiently accurate manner for our purpose, by giving to $\varDelta k$ a constant value; that is to say, a value independent of the range.

The coefficient relating to the variations in the resistance of the air having been calculated with sufficient accuracy, while neglecting the variations in vertical deflection, we may conclude that in a well established system the latter variations are too small to have any appreciable influence upon the errors of the projectiles.

⁂

An examination of the formulas and of the graphic sketch giving the errors produced by each group of causes, leads us to the following remarks:

1. Assuming that, for different charges, the variations in initial velocity are proportional to the initial velocity, that is to say that $\frac{\varDelta k}{k}$ remains almost constant, the errors of the projectile resulting from the variations in the initial velocity, vary inversely with the square of that velocity. The advantage of high velocities for accuracy of fire against a vertical target, is then obvious.

2. The errors prodnced by the variations in initial velocity decrease, but very slightly, with the caliber; that results from the presence of $\cos^2\varphi$ in the denominator.

3. For similar projectiles, of different caliber, the errors due to the resistance of the air decrease in proportion to the caliber, $\varDelta k$ being a constant fraction of k, which is itself proportional to $\frac{R^2}{m}$, while m is proportional to R^3.

ERRORS IN RANGE.

We can calculate the errors in range by proceeding with the equation giving the range,

$$\sin 2\varphi = \frac{gx}{v^2}\left(1 + \tfrac{2}{3}kx\right),$$

as we have with the equation of the trajectory in order to get the vertical errors; by substituting in the expression above, $x + \varDelta x$

for x, $\varphi + \Delta\varphi$ for φ, $v + \Delta v$ for v, and $k + \Delta k$ for k, we shall obtain finally:

$$(\Delta x)_\varphi = \frac{2v^2\varphi}{g} \frac{\cos^2\varphi}{1 + \frac{4}{3}kx} \Delta\varphi;$$

$$(\Delta x)_v = \frac{2}{v} \frac{x}{1 + \frac{4}{3}kx} \Delta v;$$

$$(\Delta x)_k = \frac{2}{3} \frac{x^2}{1 + \frac{4}{3}kx} \Delta k.$$

We should find these same results by dividing the vertical errors by the tangent of the angle of fall at the center of impact in the horizontal plane, for a range x.

$$\frac{dy}{dx} = -\tan\theta = \frac{gx}{2v^2\cos^2\varphi}(1 + \tfrac{4}{3}kx)^*$$

The following table gives the results of the calculations.

Ranges	ERROR IN RANGE CAUSED BY VARIATION IN						Total Error.	
	Angle of Departure.		Initial Velocity.		Resistance of Air.			
	8c Gun	9c Gun	8c Gun	9c Gun	8c Gun	9c Gun	8c Gun	9c Gun
meters.	m.	m.	m.	m.	m.	m.	m.	m.
200	13.39	14.00	1.09	1.13	0.188	0.144	13.46	14.05
500	11.85	12.73	2.414	2.58	1.039	0.823	12.09	13.01
1000	9.93	11.04	4.056	4.48	3.492	2.864	11.27	11.83
1500	8.53	9.70	5.246	5.95	6.774	5.70	12.08	12.70
2000	7.40	8.60	6.133	7.12	10.584	9.089	14.29	14.40
2500	6.48	7.66	6.854	8.07	14.751	12.87	17.50	17.01
3000	5.69	6.81	7.4229	8.85	19.170	16.95	21.32	20.29

Plate II gives for the 8c and 9c shells fired with heavy charges the curves of partial errors and total error in range.

It is important to observe that the errors are measured along the line of fire passing through the center of the muzzle, and not along the ground. The difference is of no importance at long range, but of considerable importance at short range. Figure 5, in which *OA* represents the mean trajectory, *AB* the error along the line of fire, and *AC* the error along the ground, sufficiently shows the difference between the two latter.

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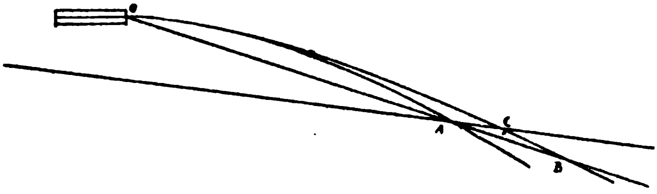
* The only difference would be that $(\Delta x)_\varphi$ thus calculated, would have in the numerator $\cos^2\varphi$ instead of $\cos 2\varphi$; but $\cos 2\varphi$ being equal to $\cos^2\varphi - \sin^2\varphi$, and this last term being very small for flat trajectories, the two formulas are nearly identical: at 2000 meters for the 8c shell $\sin^2\varphi$ equals 0.007 $\cos^2\varphi$.



From the examination of the formulas and the curves we draw the following conclusions, of which several are otherwise evident.

All things equal:

1. The error due to variation in the angle of departure, considerable at small angles, reaches a minimum at $\varphi = 45°$ (or rather about 45°, for the formula ceases to be very accurate for much curved trajectories). The error increases very rapidly with the initial velocity; it also increases with the caliber ($\cos 2\varphi$ increasing and k decreasing in this case).

2. The error due to variation in velocity, which may be thus written,

$$2 \frac{1}{\frac{1}{x} + \frac{4}{3}k} \frac{\Delta v}{v}$$

increases with the range, but less rapidly than it; this error, especially at long ranges, decreases when the initial velocity increases, even if Δv increases proportionally with v, because k also increases; finally it increases slightly with the caliber in consequence of the decrease in angle of fall.

3. The error due to the resistance of the air increases rapidly with the range.

4. The total error, considerable at short ranges, decreases at first with the range, reaches a minimum at moderate ranges, and then increases again very slowly; it thus remains nearly constant during a long course of firing.

It is most necessary to remember that the conclusions at which we have arrived, for both the vertical errors and the errors in range, *relate to practice for several hours, during a wind whose force and direction may be considered as the mean for the plains of Northern Belgium, and on a range oriented as is that of Brasschaet.* If any one of these conditions should be changed, the mean error due to the resistance of the air, and the resistance of the air, and the total error, would undergo changes that might be very important.

We see, then, the value of knowing the experimental errors that we have called *intrinsic*, that is to say errors that occur when the atmospheric changes are inappreciable or without effect. Unfortunately, in order to attain to this knowledge, it would be necessary to have experimental data gotten at long range, during very short practices, and while there was no wind, and such data we lack. However, we shall collect here the following experimental firings, whose exact duration we do not know, though it ought scarcely to have been more than two hours, and which have been executed during not unfavorable weather.

Practice with the 8^c shell.

Range.	No. of shots.	Error in range.
1800	26	$11^m.51$
1800	25	$11^m.33$
1800	?	$11^m.10$
2200	27	$9^m.82$

Calculating by means of our formulas, the mean error in range for the same shell, *under the supposition that no change took place in the resistance of the air*, we should find for that error at 2000 meters, $9^m.60$. In the firings above, then, very unimportant changes in the density of the air and in the velocity of the wind would have been sufficient to cause the mean error to rise from $9^m.60$ to about $10^m.50$.

This comparison seems to show that, just as we have said in beginning of this discussion, the variations in weight, in diameter, in shape, and in surface of the projectiles, as well as the variations in the tangential resistance of the air due to the conical movement of the axis of symmetry, are to have but a slight effect. *Hence, in a very short target, during a wind that underwent only small changes, the vertical errors and the errors in range of steady projectiles would be almost entirely produced by variations in the angle of departure and in initial velocity—changes in resistance of the air being neither 0, nor even very small, but remaining almost without effect up to very long ranges.*

These conclusions would be particularly accurate for large calibers; for the larger the caliber, the smaller the effect of atmospheric changes. Under these conditions (unless it be a question of a long practice during a pretty variable wind blowing in the direction of the line of fire) the curve representing the total errors, will approximate very closely to a curve gotten from combining the right line that represents the effects of variations in angle of departure, with the curve that represents the effects of variations in initial velocity.

We have traced that resultant on the diagram giving the errors in range. We see that, under the special conditions we have just named, the errors in range would go on decreasing with the range, over the greater extent of the trajectory.

Calculation, as well as inspection of the diagram, shows that, the higher the initial velocity, the more this fact is emphasized.

If, instead of a trial practice under chosen atmospheric conditions, it were a question of service practice of long duration held at Brasschaet, under any atmospheric conditions whatsoever, it would result from the considerations above that (for a steady projectile of another caliber than 8^c or 9^c, but of nearly the same mean velocity over its trajectory) the value of Δk might be fixed, *a priori*, at about 0.025 of the value of k.

In order to verify some of the conclusions that precede, we shall make use of the trial practices, held during comparatively favorable weather, with the 12^c steel guns, model 1862. As it is a question of a pretty large caliber and of practices of short duration, the conditions in which these experiments have been made resemble very much those which are needed in order to get the intrinsic error.

The initial velocity is 353 m., and the mean variation in velocity, calculated by means of the 72 shots in Appendix III, has been found to be $1^m.35$.

The variation in the angle of departure has been deduced from the 240 shots fired at 200 m. or 400 m.

The mean errors were :

				In height.	In range.
at 200	m. for	100	shots	$0^m.10$	$0^m.14$
at 400	“	240	“	0.28	0.26
at 800	“	44	“	0.69	0.73
at 1200	“	80	“	0.99	0.89
at 1800	“	97	“	1.49	1.41
at 2200	“	135	“	2.04	1.83
at 2600	“	25	“	3.02	2.61
at 3000	“	87	“	3.25	2.61
at 3800	“	68	“	7.07	4.37

Plate III gives: the right line representing the errors caused by the variation in the angle of departure ; the curve representing the errors due to variations in initial velocity ; and finally the total error composed of these two.

The agreement between the results of experience and those of calculation is so marked, that one may wonder whether chance has not contributed to it. In any case, up to nearly 3000 m. the influence of the variation in resistance of the air is not observed: beyond 3000 m. it is seen, for at 3800 m. the computed error is $1^m.90$ smaller than the observed error, $7^m.07$.

Let us yet remark that the new powders seem, so far, much less regular than black powder; their use, then will give an even more preponderant influence to the variations in initial velocity, in comparison with which the variations in the resistance of the air will become almost negligible in practice.

LATERAL ERRORS.

We shall here consider only firing done on a platform, or at least assume that great care is taken to assume the axle's being horizontal at each shot. Under these circumstances, the small errors that may arise from the inclination of the trunnions are without effect, as a numerical test will show.

The results collected in Appendix IV were gotten under these conditions.

Primary Errors. The setting of the sight deviation, the aiming, the reaction of the carriage and of the ground, the recoil, the vibrations of the gun, the action of the gas upon leaving the muzzle, and the eccentricity, cause, at each shot, the vertical plane passing through the first element of the trajectory not to coincide with its mean position. Excepting the error in aiming, all the other errors, or at least their lateral components, produce in a plane passing through the axis of the bore and perpendicular to the plane of fire, a mean angular error that is independent of the distance to the target.

From this there results at a distance x a lateral error

$$\Delta z = \frac{x}{\cos\varphi} \tan\psi'.$$

But in direct fire the value of $\frac{x}{\cos\varphi}$ is always very near unity (for the 8^c shell at 2000 meters $\frac{1}{\cos\varphi} = 1.0046$); we may, then, neglect this factor and reduce the above expression to

$$\Delta z = x \tan\psi'',$$

as if the errors occurred in a horizontal plane.

The lateral error due to aiming also occurs in this horizontal plane, is added to the preceding, and with it causes a total angular error whose mean is ψ': the lateral error $\Delta_1 z$ thus produced at the distance x will be simply:

$$\Delta_1 z = x \tan \psi'.$$

2. *Variations in Drift.* The drift then comes in: it is known that, in the case of direct fire, the equation that represents it is practically

$$z = B t^2,$$

t being the time of flight, and B a constant that, for the 8^{c} shell is equal to 0.062*, and for the 9^{c} shell to 0.069*, both shells fired with heavy charges.

For the shell that has the mean variation in drift relatively to the mean drift, the coefficient B becomes $B + \Delta B$ and the time of flight for the distance x is $t + \Delta t$; the error due to this cause will then be represented by

$$\Delta_2 z = \sqrt{(\Delta B t^2)^2 + (2 B t \Delta t)^2}.$$

If we calculate the last term under the radical by using the following values relating to the 8^{c} shell at 2000 meters:

$\Delta t = 0^s.026$ as a mean, according to the discussion of the variations in time of flight;

$t = 6^s.7$;

we shall find $2 B t \Delta t = 0^m.003$; this term is therefore absolutely negligible and there will remain for the mean error due to drift

$$\Delta_2 z = \Delta B t^2.$$

3. *Errors caused by the wind.* The wind can have no other effect than that of adding to or subtracting from the drift: under the action of the wind the projectile is differently deflected, and there results an error that may be combined with the preceding. We should attain the same end by giving to the wind a constant force, whose component perpendicular to the plane of fire would cause the projectile to be deflected. As, in the lateral direction, the velocity of the projectile is very low it will not be affected by the resistance of the air; hence the distances passed over will be proportional to the square of the time:

$$\Delta_3 z = M t^2,$$

M being the coefficient corresponding to the error of the mean wind.

The total lateral error, including all the causes, will then be expressed by

$$\Delta z = \sqrt{(x \tan \psi')^2 + (\Delta B t^2)^2 + (M t^2)^2};$$

---

* See our discussion of the trajectory: it must be observed that the values of B for the three calibers are 0.062, 0.069, and 0.090, and not 0.69, 0.62, and 0.90, as were erroneously printed.

or more simply, placing

$$Q = \sqrt{(\Delta B)^2 + M^2}$$

$$\Delta z = \sqrt{(x \tan \Psi)^2 + (Qt^2)^2}.$$

This relation is the equation of the curve of lateral errors. By applying it to the trajectories of the 8^c and 9^c guns, premises and reasonings analogous to those made use of in the discussion of vertical errors, will lead to determining the term representing the angular error by the results of the firing at 200 and at 400 meters (Appendix IV). These results give:

for the 8^c gun $\tan \Psi = 0.0005$,
for the 8^c gun $\tan \Psi = 0.0007$,

so that the right lines, $x \tan \Psi$, are accurately determined (Plate IV).

The total error being known from experience, the coefficient Q will then be found from the equation, or better, from graphical construction. For reasons often set forth in this article, and conformably to the 2nd corollary of the law of the composition of errors, these is no occasion for considering here practice at less than 1350 meters.

By means of the data in Appendix IX, and of the calculated times of flight, we shall thus make the following table:

RANGE. meters.	8^c SHELL.		9^c SHELL.	
	Number of shots.	Value of Q.	Number of shots.	Value of Q.
1350	400	0.051	400	0.049
1400	1380	0.044	1140	0.035
1500	320	0.038	144	0.038
1600	1306	0.048	1176	0.035
1800	490	0.037	670	0.027
2000	94	0.059	"	"
2200	82	0.036	111	0.020
2500	"	"	40	0.016
3000	"	"	65	0.022
Mean beginning with 1350 m.	4072	0.0445	3746	0.0344

These mean coefficients have enabled us to trace the curves

$$\Delta z = Qt^2;$$

and finally the total error has been deduced by graphical construction. The results of practice are also shown on the diagram.

The lateral errors of practice are more irregular than the vertical errors, so the values of Q vary noticeably from their mean; especially when the number of shots is small. These anomalies arise from two causes principally:

1. The very variable action of the wind is much more important in the case of lateral errors than in that of vertical errors.

2. The few series, having been gotten in a number of cases from only one or two target practices, do not correspond to a mean of the atmospheric variations. This remark applies especially to the firing at long ranges done in 1861-62, when exceptionally calm weather was chosen for the purpose of finding out the characteristics of some newly introduced pieces of ordnance, and determining the rules for firing them: errors found under such circumstances must have been smaller.

The time value of the mean coefficient appears in the firing at 1350, 1400, and 1600 meters, in which nearly all the the batteries were successively engaged; and of this firing that done at 1400 and 1600 meters deserves most attention, the component due to drift and wind here becoming large enough to be determined with accuracy. At these ranges, the coefficients calculated by substituting in the equation are nearly the same: moreover, they happen to agree almost exactly with the general mean.

The 8^c and 9^c projectiles are almost alike, and over a range of 3000 meters their mean velocity is nearly identical. Also, if we form the ratios:

1. Between the quotient of their cross-sectional surfaces (proportional to the squares of their radii) divided by their weight,

$$\frac{R^2}{W} : \frac{R'^2}{W'} = 1.16;$$

2. Between the coefficients Q corresponding to their error due to the wind and to variations in the drift,

$$\frac{0.0445}{0.0344} = 1.29;$$

we find values that are very close together.

⁂

We have also applied our formulas to the results of the experimental firing done with the 12^c steel gun, model 1862.

The angular error was deduced from the data on page 57.

The coefficient Q was calculated by substitution in the equation. As it is here a question of a larger caliber and experital practice of short duration, during not too unfavorable weather, the value of that coefficient ought to be smaller: indeed we find $Q = 0.020$.

Plate V gives the calculated errors and the results of practice up to 3000 meters.—(At 3800^{m} calculation gives $4^{m}.80$, and practice gives $4^{m}.37$).

The coincidence is again very satisfactory.

VARIATIONS IN TIME.

These variations are of interest in the employment of time fuses.

The mean variation Δt in the time of flight of different trajectories is gotten, as we have seen above, from the equations:

$$\overline{\Delta t}^2 = (\Delta t)_v^2 + (\Delta t)_k^2 ;$$

$$(\Delta t)_v = \frac{x}{v^2 \cos \varphi}\left(1 - \frac{1}{2} kx + \frac{1}{2} k^2x^2\right) \Delta v ;$$

$$(\Delta t)_k = \frac{x^2}{2 v \cos \varphi}\left(1 - \frac{2}{3} kx\right) \Delta k.$$

For the 8^{c} shell* we shall get from these formulas, making $\Delta v = 1^{m}.13$, $\Delta k = 0.022$, and $x = 2000$ m:

$$\Delta t = 0^{s}.026.$$

The remaining velocity of the shell, at 2000 meters, being 245 meters, the mean error in range (corresponding to the above variation in time) is $6^{m}.37$; this last figure multiplied by the factor, 0.845, will give the probable error, $5^{m}.40$. So, assuming the shells to be provided with time fuses of perfect action, the normal points of explosion would fall within a length of 44 meters.

The fuses themselves giving much greater variations in interval, we may conclude that the influence of the irregularity of the trajectory is here secondary.

But if, through the use of a new powder, the variations in initial velocity should become much more important, we see that they might very noticeably increase the variations due to the irregularity of the fuses.

(To be Concluded.)

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* We have made the calculation for the shell, since we lack the necessary known qualities for the shrapnel.

* * *

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

The Hotchkiss 1-Pounder ($37\ ^{m}/_{m}$) Automatic Machine Gun.

The 1-pounder Automatic Machine Gun is based upon the same principle as that of the well known Hotchkiss Rifle Calibre Machine Gun, but the details of the mechanism have been greatly modified in order to simplify the construction and strengthen the breech closure. The gun consists of 33 component parts, of which 15 comprise the operating mechanism, and in the latter are contained no screws or pins, and only three springs, of which one alone is essential to the working of the gun. All of the motions of the mechanism are parallel to the axis of the gun, and therefore the accuracy of fire is not affected by the vibrations. The entire mechanism may be completely dismounted or assembled in about thirty seconds, and without the use of tools, and has been so designed and simplified that it may be operated and cared for by an enlisted man of ordinary intelligence.

The firing gear is arranged for firing single shots or continuously, at will, the rate of fire in the latter case attaining 200 rounds per minute. The gun is loaded by means of feed-strips holding 8 or 10 rounds, or by belts of 25 or 50 rounds. The rate of fire is the same for both methods of loading, the strips being recommended except when the gun is mounted in a confined position, such as in boat service, small turrets, and the like. Both strips and belts are made wholly of mild steel, and may be employed indefinitely without reforming, and being entirely metallic are not affected by water and climatic conditions. The feed mechanism is positive and independent of gravity, and is not influenced by the elevation or depression of the piece.

The cartridges not are fed into the chamber until the instant of firing, and consequently are not subjected to excessive temperature in case the firing is suspended with the gun loaded. The barrel is fitted with a radiator, which absorbs a great portion of the heat developed by the powder, and obviates the necessity of a water jacket.

GENERAL PRINCIPLE.

A gas port is drilled into the barrel of the gun, a few calibres from the muzzle, and brings the bore into communication with a cylinder parallel to and beneath it. Within the cylinder is a piston, and when on the discharge of the gun the projectile passes beyond the gas-port, the powder gas enters the cylinder and throws the piston to the rear. The rearward motion of the piston compresses the main-spring, and this when not prevented by the trigger, immediately returns the piston to its original position. The remaining parts of the mechanism are actuated by this reciprocating piston, and perform the operations of opening and closing the breech, extraction and ejection of the cartridge-case, feeding, loading, and firing.

AMMUNITION.

The ammunition is assembled in a similar manner to that used in breech-loading small arms, and consists of the projectile, to the base of which is secured a cartridge-case, containing a wad and the powder charge, and in the base a primer for central fire.

Cartridge-case.—The cartridge-case is solid drawn, and is identical with that supplied for the Hotchkiss Revolving Cannon.

Projectiles.—The projectiles are of three kinds: common shell, steel shell, and canister. The two descriptions of shell do not materially differ in construction, except that the base of the steel shell is an independent piece, whilst that of the common shell is a part of the casting. Rotation is given by means of a copper driving band, which is seated over a series of small grooves cut around the wall of the shell. The canister consists of a thin sheet brass case shaped to the profile of the common shell, and containing 28 hardened lead balls packed in saw-dust.

Fuses.—For Naval service, the common shell are fitted with the Desmarest direct action point percussion fuse. This fuse, the construction of which is clearly shown, is arranged to act close behind the object perforated.

For land service, the common shell are fitted with the Hotchkiss point percussion fuze. This is of the inertia type, and is arranged to act sentitively on the graze.

The steel shell are fitted with the Hotchkiss base percussion fuse, in order that the point of the shell may be highly tempered to obtain a maximum of penetration. This fuze is also of the inertia type, and acts equally well on graze or direct impact.

Powder-charge.—The cartridges are normally loaded with a charge of 40 grammes of French smokeless powder, with an igniter of 2 grammes. Black powder is not employed with the Automatic Gun, as the smoke makes accurate aiming impossible, and the residue clogs the mechanism.

MOUNTINGS.

Mountings have been designed and constructed to meet all requirements of Naval, Field, and Garrison Service, and comprise deck, rail, masthead, and boat mountings, landing and field carriages, barbette and casemate carriages, etc.

WEIGHTS AND MEASUREMENTS.

Diameter of bore	$^{m}/_{m}$	37	or 1.45 in.
Weight of gun complete	kgs.	170	or 374 lbs.
Weight of charge	grms.	40	
Weight of projectile	"	450	
Weight of complete cartridge	"	650	
Initial velocity	met/sec.	500	or 1640 f. s.
Total weight of gun carriage	kgs.	265	
Maximum angle of elevation	degs.	+ 17	
Maximum angle of depression	"	− 14	
Weight of gun in battery	kgs.	435	
Weight of limber empty	"	287	
Number of rounds carried		288	
Total weight of limber fully equipped	kgs.	575	
Weight of caisson-limber empty	"	287	
Weight of caisson-body empty	"	288	
Number of rounds carried by caisson		576	
Weight of caisson fully equipped	kgs.	1100	
Weight behind gun team	"	1010	

The Hotchkiss Automatic Machine Gun.

The Hotchkiss Automatic Machine Gun in general design, and in detail, is a radical departure from all former types. It may be arranged to fire any model of small-arms ammunition.

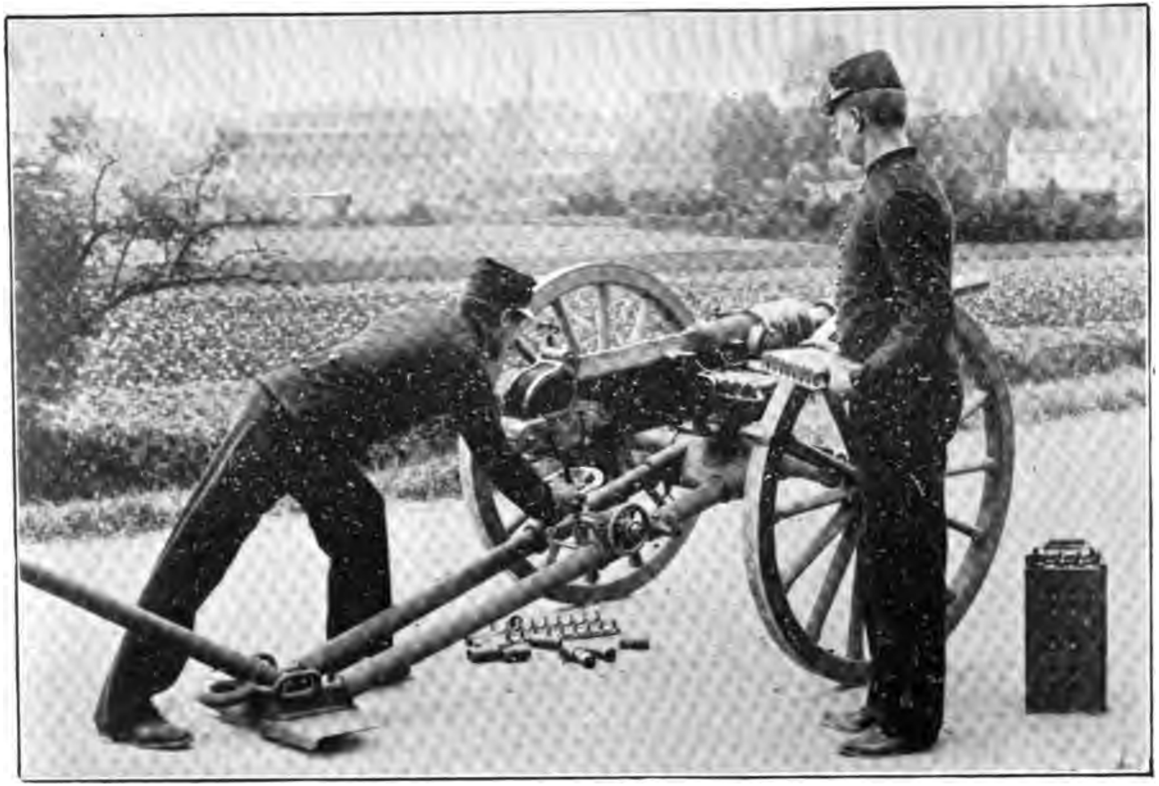


Plate I. Field Carriage.

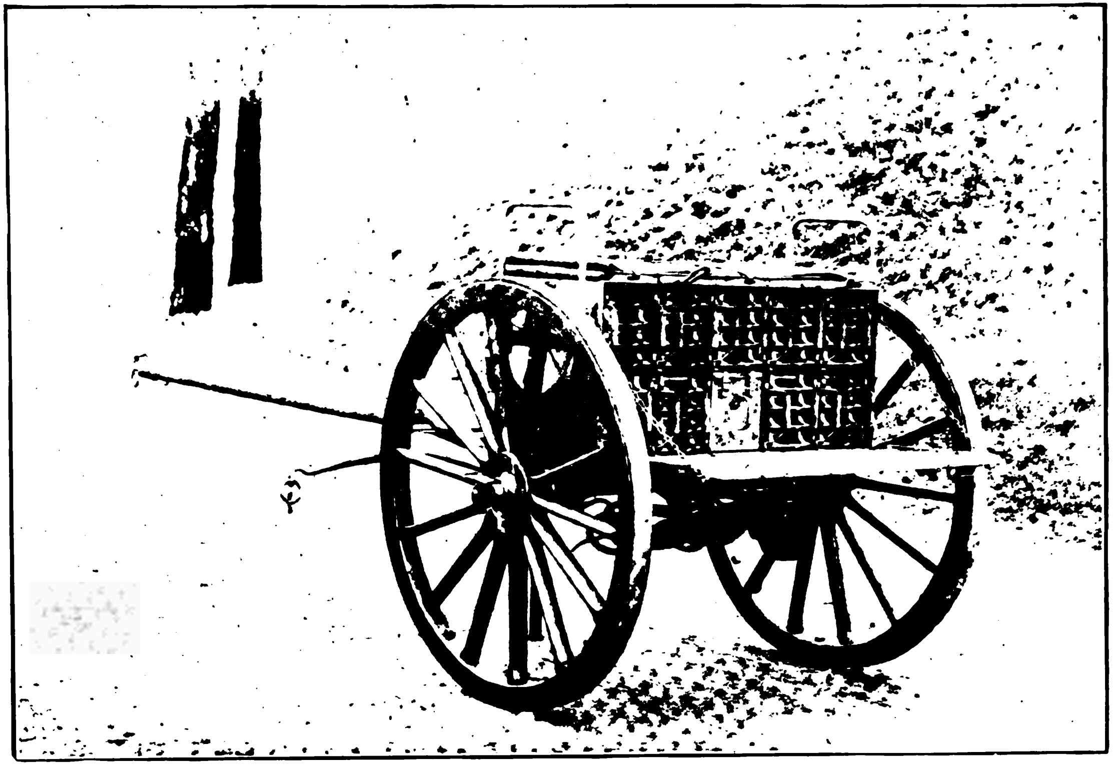


Plate II. Field Limber.

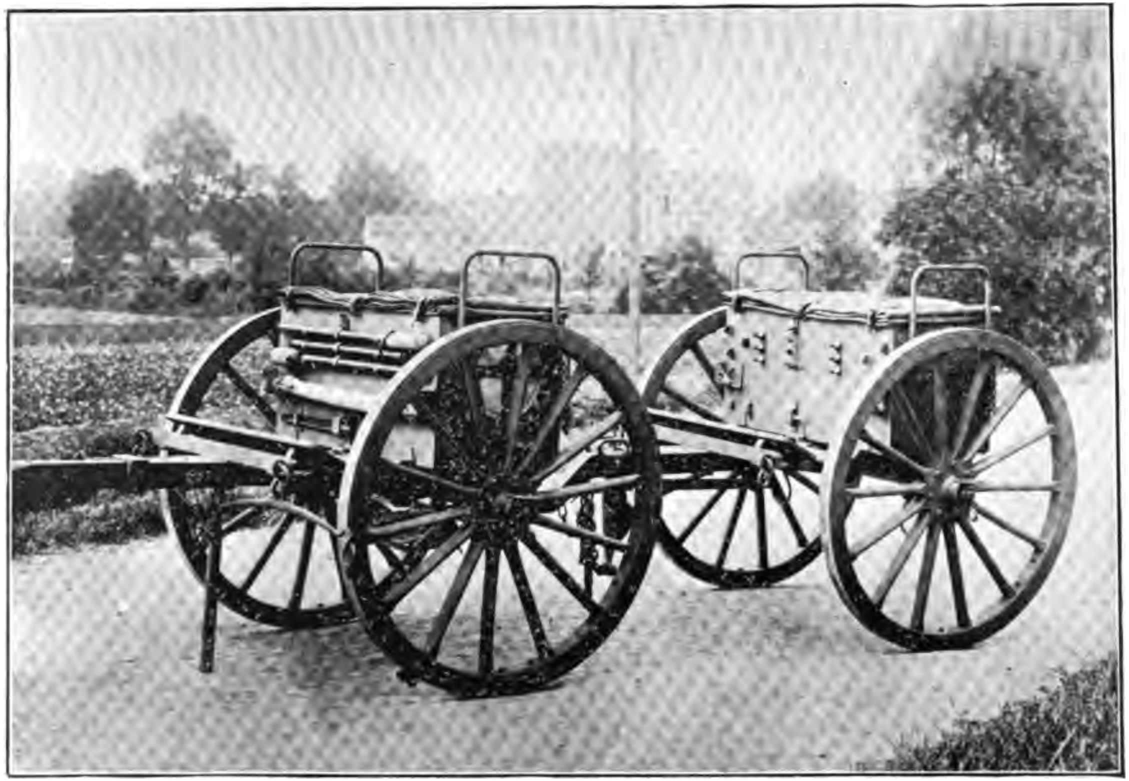


Plate III. **Field Caisson.**

The principle underlying the construction of this gun, is the utilisation of a portion of the powder gas, by means of which, after the first cartridge has been fired by hand, the various operations of the breech action, feeding mechanism, firing and extraction of empty cartridge-cases, are performed automatically, but under complete control of the gunner.

Slow fire may be delivered at any rate up to about 100 rounds per minute, and rapid fire up to,from 500 to 600 rounds per minute. The weight of the gun is 24 klg. = 53 lbs.

GENERAL DESCRIPTION.

The gun consists of a single barrel, screwed into the front of the receiver which contains the operating mechanism; below and parallel to it is secured a hollow cylinder which is in communication with the bore through a port drilled through the barrel. Contained in this cylinder is a piston, on which are formed suitable cams for operating the breech-block, the firing, and the feed mechanism. On discharge, as soon as the bullet has passed the port connecting bore and cylinder, the powder gas enters a chamber in the front end of the cylinder and throws the piston to the rear, where it is held by a sear. On releasing the sear, by pressing the trigger, the piston is thrown forward to its initial position by the main-spring. It is obvious that if the sear is held out of engagement by pressing the trigger, and the supply of cartridges be kept up, the piston will have a constant reciprocating motion.

The piston engages with the breech-block, and by its motion opens the breech, pushes the cartridge into the chamber, closes the breech and fires. On opening the breech it extracts the fired cartridge-case, and brings a fresh cartridge to the loading position, performing, in other words, the functions of a soldier's hand when operating a straight-pull rifle.

The cartridges are carried in flat brass feed-strips, having a length of about 38 centimetres, and each containing thirty rounds. Each feed-strip is packed in an ordinary pasteboard box, from which it is fed directly through the gun.

The feed mechanism comprises a feed-wheel which engages in cams cut in the piston, and registers with openings formed in the feed-strip; each backward and forward motion of the piston brings a fresh cartridge in line with the chamber, ready to be pushed home by the breech-block, and fired.

The gun is fitted with a shoulder-piece, and with a pistol-grip and trigger for controlling the fire. Aiming and firing are therefore carried out, as in all Hotchkiss guns, with the same facility as when firing a rifle from a rest.

Two men are required to work the gun, one to load, and the other to fire, but a single man can work it in case of necessity.

If the trigger be held back, the piston is free to move forward again under the action of the main spring, and the fire will be kept up continuously and automatically, until the supply of cartridges in the strip is exhausted.

DISTINCT AND IMPORTANT CHARACTERISTICS OF THE SYSTEM.

Simplicity.—The gun consists of but thirty parts (exclusive of sights, but including barrel, shoulder-piece, etc.): there are no screws or small pins, and but four springs in all, of which but one—the main-spring—is essential to the working of the gun. All parts of the mechanism are so designed that it is impossible to assemble them incorrectly. No tools are necessary to dismount or assemble the mechanism, except for unscrewing the barrel and the cylinder, for which a spanner is supplied.

Ammunition Supply.—The feed mechanism is positive, and independent of gravity. The cartridges are preferably carried in feed-strips of elastic brass, on which three rows of clips are formed, which embrace and hold the cartridges at the neck, the middle of body, and the head. The cartridges pack closely together, a feed-strip holding thirty rounds being only about thirty-eight centimetres long.

The feed-strips are packed in pasteboard boxes, from which they may be fed directly into the gun. Packed in this manner, the feed-strips stow very compactly in the ammunition boxes, and are thoroughly protected against jolting or accidental damage.

The feed-mechanism is so devised that it withdraws the feed-strip from the packing box, brings the cartridges one by one, by positive motion, in line with the chamber, and ejects the empty strip. The feed works equally well at any angle of elevation or depression.

The system of loading with feed-strips gives the officer better control over the rate of fire and expenditure of ammunition, than is possible with any form of belt-feed.

The feed-strips being made of metal are not affected by rain or dampness, and may therefore be stored for any length of time without deterioration.

CARRIAGES AND MOUNTINGS.

Several types of mountings for this gun have been designed, both for field, mountain, and naval service.

For land service the gun is generally used with the field tripod, and transported on pack animals.

On one pack is carried the gun, the tripod, the spare parts and implements, and 600 rounds of ammunition.

On each ammunition pack is carried six chests with 1,800 cartridges, in feed-strip.

The saddlery is similar to that used for light mountain artillery. Gun and tripod are carried on bearing hooks secured to the saddle. The ammunition is carried in two chests secured above these hooks. The accessories and spare parts are carried in a hold-all secured to the saddle frame.

Weight of gun-pack :—

(*a*) Saddlery, with gun and tripod, pouches, waterproof cover, etc.	66 lbs.
Gun	52.8 "
Tripod	39.6 "
Spare parts and implements	17.6 "
2 chests with 600 cartridges	61.6 "
Total	237 lbs.

Weight of ammunition pack :—

(*b*) Saddlery, waterproof cover, etc	50.6 lbs.
6 chests with 1,800 rounds	184.8 "
Total	235 lbs.

TRAVELLING CARRIAGE.

(*Plate II.*)

The travelling carriage is designed to meet the requirements of service with cavalry or infantry, and to be moved at all gaits over any kind of ground. Fitted with a guide-bar and drag-ropes, instead of a pole, it may be used as a Naval landing carriage. The weights are well within the limits for two-horse draft.

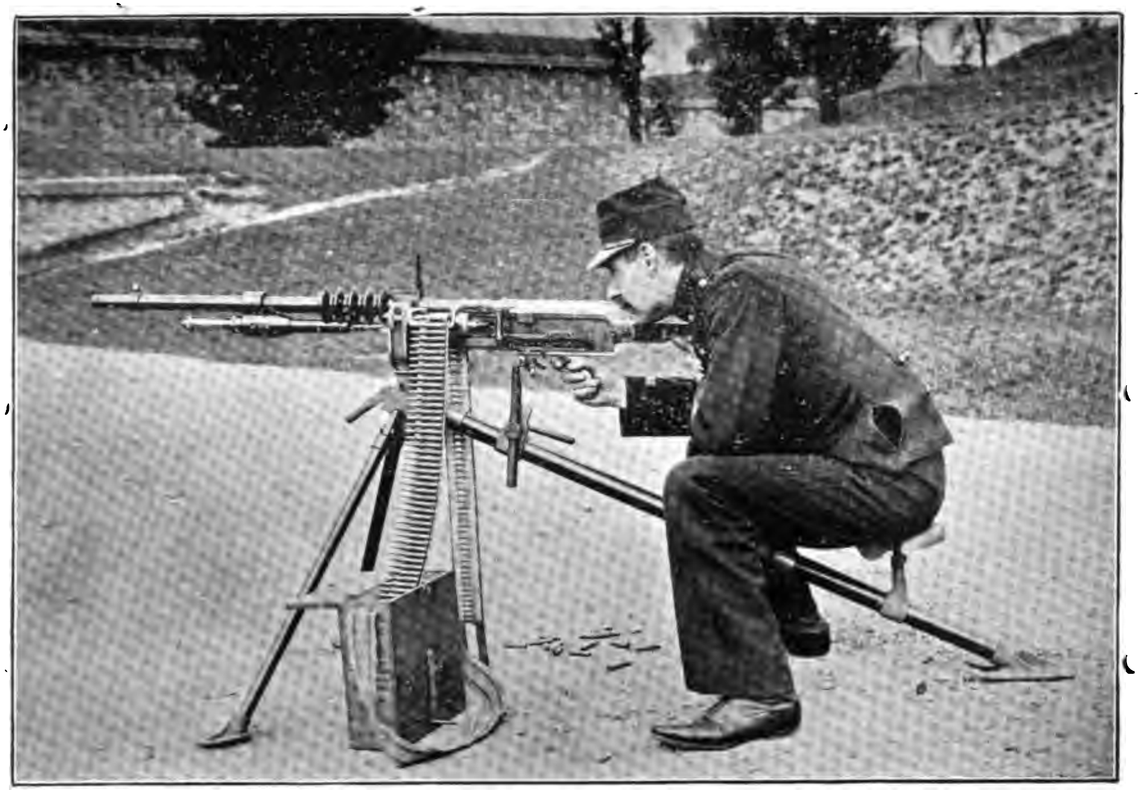


Plate 1. Gun on the Field Tripod.

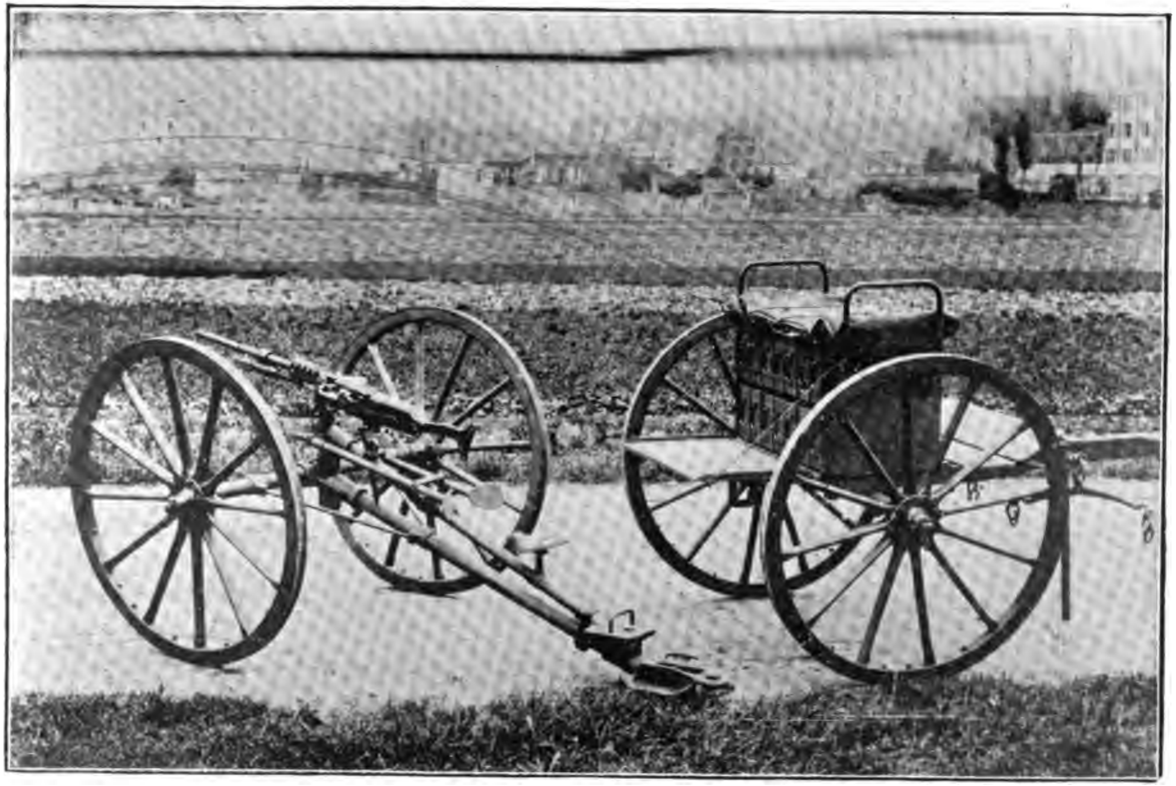


Plate II. Travelling Carriage.

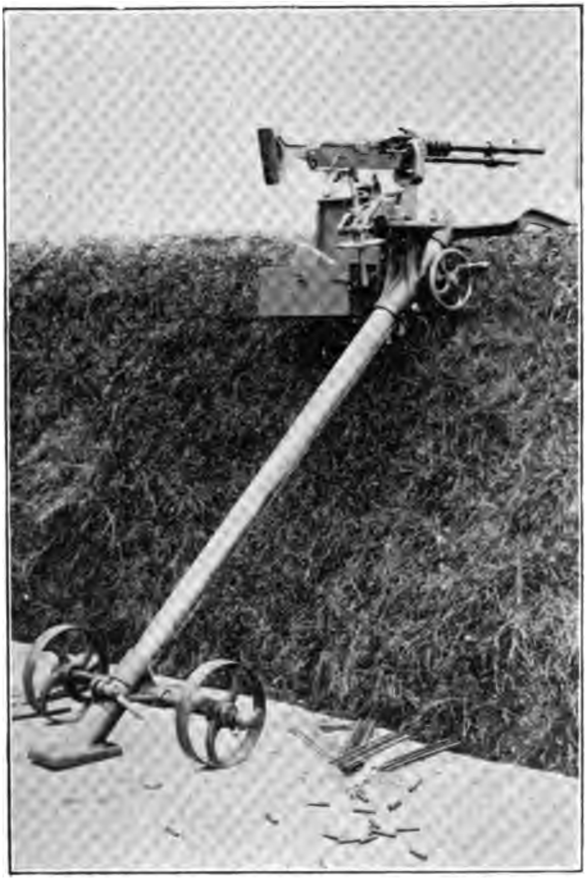


Plate III. **Parapet Mounting.**

Total weight of gun mounted	376 lbs.
Total weight of limber, loaded..	870 "
Total weight behind team	1,246 "

PARAPET MOUNTING.

(*Plate III.*)

This mounting is designed for service in field works, and permanent fortifications. The body of this mounting is formed of a steel tube, to the upper end of which is fitted a pair of arms for supporting the mounting on the crest of the parapet. The lower end is terminated by a heel plate. The upper carriage which supports the gun, is carried by the tubular body, and may be raised or lowered by means of a rack and pinion. It is provided with elevating and traversing gear, and with lugs for supporting an ammunition chest. An adjustable axle with rollers is fitted to the lower part of the tubular body, and provides means for readily shifting the gun from one position to another.

Weight of mounting, complete	187 lbs.

Machine Guns of Calibre.

Great capital has been made out of the alleged superiority of certain items in the Boer armaments over our own. There is, notably,the case of the 1-pounder Maxim machine guns, now more familiarly known, perhaps, as the "Pom-poms," the moral if not mankilling properties of which have proved so formidable that the Government has thought fit to purchase and despatch to South Africa some of these wepons. This 1-pounder Maxim gun is the first machine gun of calibre ever used in the field. By "machine gun of calibre" is meant a machine gun throwing an explosive shell, whose weight is just low enough to allow of the narrowest margin permissible by that clause in the St. Petersburg Declaration of 1868, which enjoined that no explosive projectile less than 14 oz. in weight would be tolerated in civilized warfare. It is true that quick-firing guns of small calibre, viz., 3-pounders, have been utilized in former land campaigns—the instances will be cited presently—and these have been erroneously described as machine guns by those who do not realize the difference between the two types of weapons. A machine gun is one that is loaded and fired by machinery. A quick-firing gun is distinguished from a machine gun by the fact that it is loaded by hand and may be fired either by hand or by machinery. In both classes there is practically no recoil, or, rather, the recoil is absorbed and utilised, in the case of the machine gun to continue the loading and firing operations, in that of the quick-firing gun to return the piece back to the firing position. The machine gun is the older invention—dating as it does from the primitive type of Gatling gun used in the War of Secession, and the Reffye mitrailleuse secretly manufactured in France prior to the war of 1870—and until quite recently was limited in calibre to small-arm ammunition. The quick-firing gun was introduced at a later date, and for many years was used almost exclusively in the Navy against torpedo boats. By its power it is enabled to penetrate any armour that torpedo boats can carry, and by its rapidity and accuracy the chances of hitting in a given time are very high. It is only within the last five years, however, that the principles of the quick-firing gun have been applied to field artillery. For example in his Prize Essay of 1891, Major Benson quoted Mr. Nordenfelt as saying that the heaviest quick-firing gun he could make, of which the recoil was absorbed by arrangements in the field carriage, was a 7.7-pounder; in 1892, Colonel Langlois, of the French artillery, stated that the best quick-firing guns on the Continent fired projectiles weighing only 6.6-pounds, and did not develope a muzzle velocity of more than 1630 foot-seconds; while in the Chicago Exhibition of 1893 practically no field guns of the quick-firing type were exhibited. But what military artillerists required was that the field gun then in use, throwing shells varying in weight from 12 pounds to 16 pounds, might be converted into quick-firers, capable of doubling the normal rate of battery fire per minute. The naval weapon, with its small explosive shells, from 1-pound to 6-pound in weight, according to calibre, is naturally of little practical utility in the field. This problem, the crux of which rests in the mechanism for absorbing the recoil—a requirement easy of application to a fixed mounting, but difficult with a mobile carriage for use in the field—is only partially solved at the present day. There are numberless so-called quick-firing field implements in existence, but it is doubtful whether anyone has yet truly and definitly overcome the recoil difficulty, and some persons go so far as to assert that it can never be done.

It has been stated that the machine gun was long limited in calibre to small-arm ammunition; the first attempt to go beyond this was the Hotchkiss revolving cannon, of 1.5-inch calibre, and throwing a 1-pound shell. This weapon is composed of five parallel barrels, which are made to revolve by the action of a peculiar gearing driven by a crank on the right-hand side of the piece. While the barrels are rotating the firing pin and loading piston are moving to the rear and the extractor to the front. While the barrels stand still the cartridge is fired, the empty case extracted, and a new cartridge inserted. The rotation of the barrels then begins as before. The gun is capable of discharging eighty rounds per minute, and good results have been obtained at a range of 5500 yards. It was adopted for the United States navy, but its relatively great weight and small calibre caused it to be replaced by the Driggs-Schroeder quick-firing gun. This same drawback, experienced in all other early patterns of machine guns of calibre, militated against their being substituted for the different models of quick-firing guns, in which the distinguishing feature is the breech mechanism; the ballistic qualities, and the rapidity of fire being about the same for all guns of the same calibre. Finally, however, a machine gun of calibre, in which the weight of the equipment is proportionate to the calibre, made its appearance. This is the now well known 37 mm. Maxim, that differs from the other guns of its class by being entirely automatic; that is, after firing the first shot, if the finger is kept on the trigger, the gun will load and fire automatically till the supply of ammunition fed from belts is exhausted. This gun is made in two patterns as follows:—

	30 calibre.	42.5 calibre.
Bore	1.45-inch	1.45-inch
Length of gun	73.75-inch	94-inch
Weight of gun	4 cwt. 22 lb	5 cwt. 1 qr. 26 lb.
Cordite charge	1 oz. 110 gr	3 oz.
Muzzle velocity, foot-seconds	1800	2350
Weight of projectile	1 lb	1.25 lb.
Shots per minute	300	300

The 30-calibre gun is that adopted for use in the field, mounted upon a light wheeled carriage. Of course, the 37 mm. Maxim will soon have rivals. One is said to be already forthcoming from the French Government arsenal at Puteaux. It is a weapon of the Hotchkiss type, with a calibre of 37 mm., and throwing a 1-pound shell; it consists in all of 30 pieces, easily taken to bits and put together again, and is formed of a single barrel in front of the receiver. The cartridges are attached to a revolving brass band, which works automatically, each shot that is fired bringing the next one into position. The gun is provided with a butt, similar to that of an ordinary rifle, which the firer rests against his shoulder, with a pistol trigger and cut-off to regulate the fire. Two men are required to work the gun, one to load and the other to train and fire it. Comparatively slow firing may be executed at the rate of 100 shots per minute; with rapid firing, however, 500 to 600 shots per minute can be discharged. The gun is provided with an apparatus to prevent overheating. Various types of gun carriages may be used with it, according as it is required for mountain, field, or naval service. For mountain service—and France intends arming her Alpine Corps with a large number—a folding tripod carried on mule-back can be used; for field service it is mounted upon a wheeled carriage, provided with shields and a limber; on board ship, or on the parapets of fortresses, the gun is fixed on a pillar mounting.

The Americans, again, are reported to have effected certain improvements in the Driggs 6-pounder quick-firing gun, which entitle it as being classed as a semi-automatic machine gun of calibre. For land service the piece is moanted on what is known as a minimum recoil carriage, also designed by the Driggs Gun Company. The general appearance of this carriage is not unlike the ordinary service carriage used with the 3.2 inch field gun, but it has the addition of a recoil cylinder by which the gun is permitted to recoil independently of the trail. On either side of the trail is a tread for the gun pointer, and a shoulder-bar similar in shape to that used on the Navy mount; so that, to all intends and purposes, the gun operates in the field as it would if mounted in a fixed position. The new gun has just completely met every requirement of the most exhaustive trials at the Indian Head proving ground, making a sustained record for rapidity (at the extreme rate of seventy-five rounds per minute), that exceeds by nearly 100 per cent. the best ever reached by a gun of its calibre in any test and under any conditions, however favorable. The automatic feature may be entirely put out of operation by simply throwing up a small handle, when the gun can be worked as an ordinary hand-working gun, and as deliberately as wanted. The gun claims to have fewer parts than any hand-working quick-firing gun, and the whole mechanism can be assembled or taken down without the use of any special tools. The *New York Tribune* announces that an order has been promptly placed for fifty-one of them for mounting on the six new gunboats of the Denver class now building. This order will be followed by the manufacture of double that number for the little gunboats in the Philippines as soon as the next naval appropriation becomes available.

Recognizing, therefore, that the difficulties attending the designing of machine guns of calibre have at last been surmounted, it is necessary to inquire into their utility in the field, where, of course, they play the part of a man-killing weapon. Prior to the introduction of special land guns, quick-firing guns of small calibre had been taken from ships and utilized on land. How did these aquit themselves? During the rebellion of Herzegovina and Southern Dalmatia in 1882, the Hotchkiss 3-pounder quick-firing guns of the Austrian warships were used on land on more than one occasion with telling effect, gaining for themselves the title of "Broom of Fire." But as opposed to a badly-armed peasant rabble, this instance cannot be taken as a fair criterion. At the capture of Valparaiso in 1891, the Constitutional army relied solely upon the Hotchkiss machine quick-firing guns landed from the fleet and manned by marines for its field artillery. This again teaches nothing, since the Balmacedist artillerymen, who sympathized with the enemy, deliberately indulged in indifferent practice until the Hotchkiss batteries were within 1600 yards range, when they abandoned their guns. The last, and, indeed, the only favourable instance occured in the war between Italy and Abyssinia. The Abyssinian mountain batteries were armed with Hotchkiss 3-pounder quick-firing guns, and at Adowa these were concentrated on the Italian light muzzle-loading pieces in succession. Their fire, it is said, was so overpowering that the Italian guns were soon silenced, owing to the heavy losses in officers and men. These Hotchkiss guns were capable of going anywhere that the mountain guns opposed to them were able to penetrate, and experienced no more difficulty in finding suitable sites on which to come into action.

It is impossible to dispute the fact that except on abnormally hard ground or in rocky defiles one to three-pounder explosive shells, which burst only on impact, have their man-killing properties confined to a very restricted area. Owing to its size the projectile can be used solely as a locomotive mine—that is to say, it is impossible to adapt it to shrapnel, and its efficacy, therefore, depends entirely upon the shattering and scattering of the metal walls. These fragments, again, are comparatively few in number, and the small bursting charge limits the distance at which they can take effect. Striking a hard bursting screen this small shell may possible cause casualties among two or three men in the immediate vicinity, but plunging into earth the burst can be hardly more dangerous than that of a powerful squib. Of course, if the projectile actually strikes a man it will almost blow him to pieces; but the damage ends with the man so struck; while as the aim in warfare is to put the enemy out of action, not necessarily to kill him, this is accomplished equally well and far more economically with a projectile of small-arm calibre. It is more than doubtful, therefore, whether the great rate of fire—in the case of 37 mm. Maxim 300 shots per minute—can compensate for any, or all, of these drawbacks in aggregate. Lastly, there is the moral effect of the weapon to be considered; but this cannot be taken as an enduring asset, for men will soon discover that the bark is far worse than the bite, and act accordingly. In short, machine guns of calibre, so long as they are restricted to such small explosive shells, are only repeating on a far more expensive and troublesome scale the action of machine guns of rifle calibre, over which also they appear to possess but little superiority in range.

It is difficult, therefore, to believe that, as at present constituted, they will ever prove of any great utility in the field.

—*The Engineer*, May 11, 1900.

RANGE AND POSITION FINDING.

The Phillips Replotting Board.

Copy of U. S. Patent Office Record.

To all whom it may concern:

Be it known that I, Charles L. Phillips, a citizen of the United States, and a resident of Auburn, in the county of Cayuga and State of New York, (having my present post-office address at Fort Hancock, Sandy Hook, New Jersey,) have invented a Gunner's Replotting Apparatus, of which the following

No. 674,517. Patented May 21, 1901.

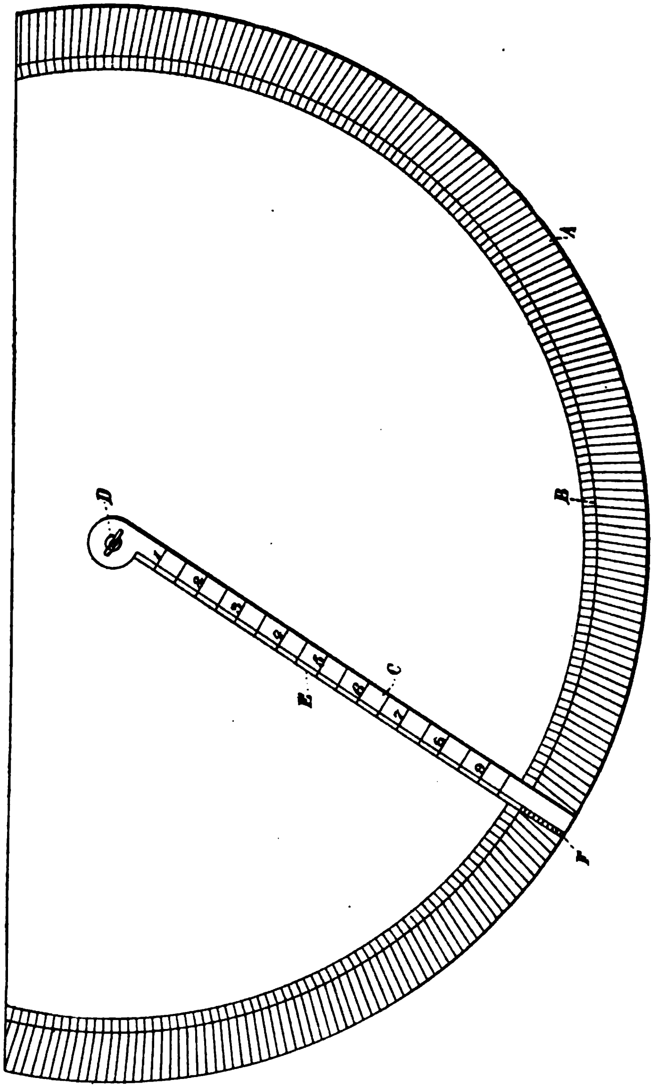
C. L. PHILLIPS.

GUNNER'S REPLOTTING APPARATUS.

(Application filed Aug. 29, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.



Witnesses
Geo. W. Naylor,
Edgar C. Mead

Inventor
Charles L. Phillips
By his Attorney
Phillips Abbott

is a specification, reference being had to the accompanying drawings, on which—

Figure 1 illustrates the table of the apparatus, shown in plan, with the protractor-scale in position upon it. Fig. 2 illustrates, likewise in plan, one of my "concentric-circle" sheets. Fig. 3 illustrates a plan view of the parts in position for operation. Fig. 4 illustrates an edgewise elevation of the apparatus, partly broken away in its medial section.

The object of my invention is to provide an inexpensive, quickly-operative, easily-transported, and practical apparatus for determining the distance and direction of any object, stationary or movable—for instance, an enemy's fort, gun-boat, or other target—from a given point—as, for instance, the gun which is to be trained upon such object—when the direction and distance of both from another given point—*i. e.*, a range finder—are known.

My invention has special application to the service of sea-coast guns in the determination of ranges based upon distance and position data furnished by the observations of a range-finder. The operation of a range-finder and the data furnished by it are too well known to require description here.

As constructed and adjusted for use the apparatus consists of a table or board A, (which may beneficially be substantially semicircular, as shown, although it may be of any other preferred form,) having upon the outer edge of its upper surface a diagonal protractor-scale B, conveniently subdivided and marked, so as to read degrees of arc, and an arm C, pivoted at the center of the protractor-scale, as at D, which is also conveniently subdivided and numbered along its fiducial edge, as at E, from the pivot outward to a point distant from its outer end not less than the width of the protractor-scale, whereby it is adapted to indicate distances according to any determined scale in a manner well known. Where the fiducial edge of the arm crosses the protractor-scale, as seen in the drawings, it is suitably subdivided, as at F, to allow the reading of minutes of arc. The space on the surface of the board or table lying within the protractor-scale is occupied by a series of concentric circles G G G, &c., which are produced upon a separate sheet of paper G′ or upon equivalent material, as shown in Fig. 2. The circles are spaced equidistantly and are numbered as may be convenient to read distances, according to the determined scale from the common center of the concentric circles. In the illustration shown (see Fig. 4) the distances indicated commence with "2000" and increase outwardly by steps of five hundred. These figures in the present case indicate lineal yards; but they may indicate any other preferred distance. On the actual sheets I usually indicate the increments in distance from the center outwardly by other lines indicating one hundred yards, or sometimes fifty yards; but for simplification of the drawings these minor subdivisions have been omitted. The subdivisions may be such as preferred. As thus constructed and adjusted the center of the pivot D represents the position of the range-finder, and the center of the concentric circles innicates the position of the gun. The distance-arm C being placed so that, as determined by the protractor-scale, its fiducial edge has the direction of the target from the range-finder, the subdivisions of the arm, reading the distance of the target from the range-finder, will fix the location of the target upon the board or table, and the reading of the concentric circle, or that one of its subdivisions which passes through this point, determines the distance or range of the target from the gun. The characteristic feature of this invention consists in this use of a series of concentric circles produced upon a seperate sheet or surface and adapted to be superposed

No. 674,517. Patented May 21, 1901

C. L. PHILLIPS.

GUNNER'S REPLOTTING APPARATUS.

(Application filed Aug 28. 1900.)

(No Model.) 3 Sheets—Sheet 2

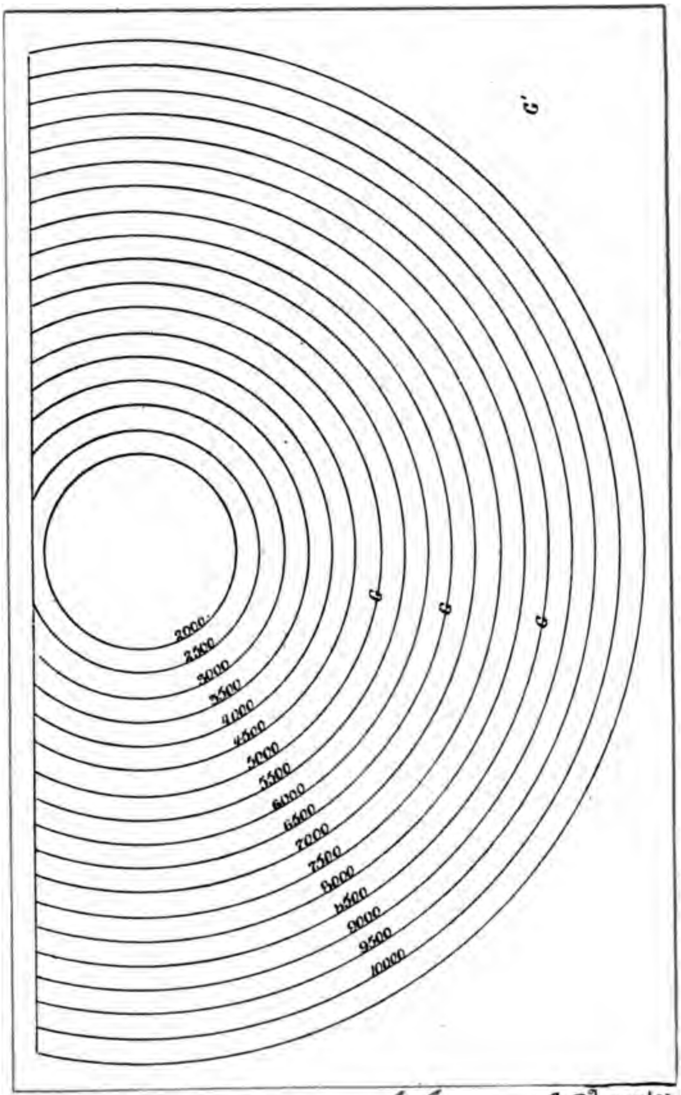


Fig. 2.

Witnesses.
Geo. W. Naylor
Edgar C. Mead

Inventor
Charles L. Phillips
By his Attorney
Phillips Abbott

No. 674,317 Patented May 21, 1901.

C. L. PHILLIPS.

GUNNER'S REPLOTTING APPARATUS.

(Application filed Aug. 28, 1900.)

(No Model.) 3 Sheets—Sheet 3

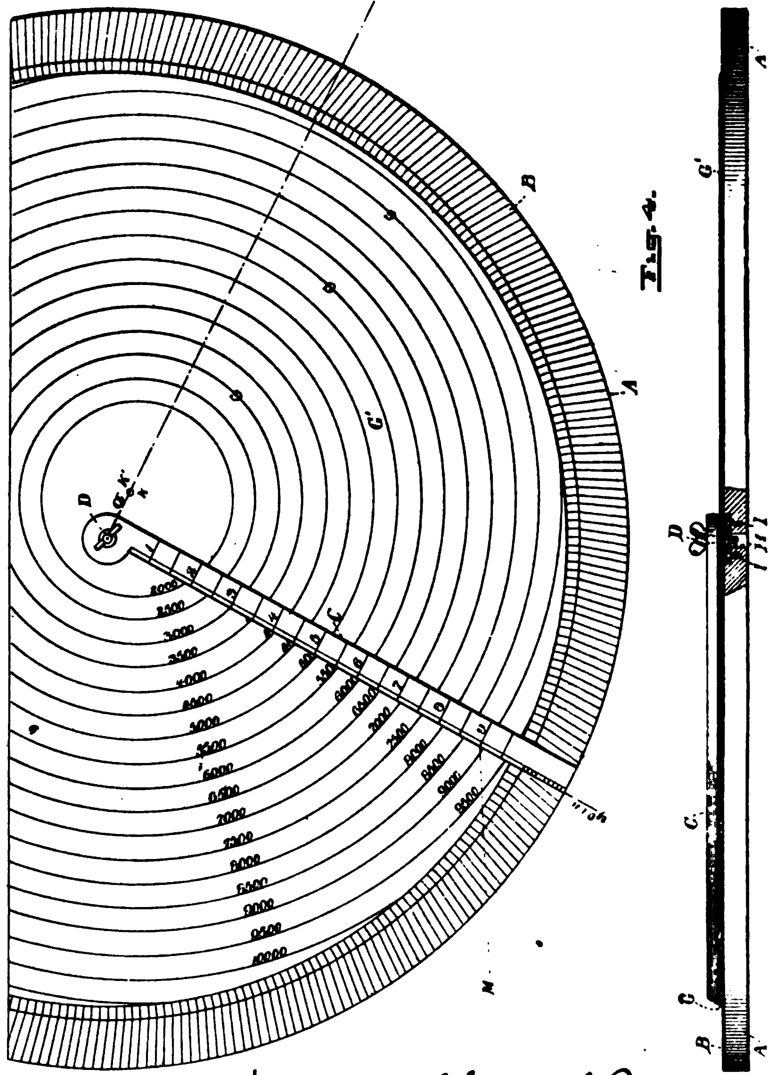


Fig. 3.

Witnesses
Geo. W. Naylor
Edgar B. Mead.

Charles L. Phillips Inventor
By his Attorney Phillips Abbott.

and adjusted upon the board or table carrying the protractor-scale in such manner that the foregoing results can be attained.

To give a clearer understanding of the apparatus, its several parts will be described somewhat more in detail, as follows:

First. The board or table A may be made of any suitable size, shape, and material. I prefer that it should be substantially semi-circular, as shown, and ordinarily from three to four feet in diameter. The size, however, will be determined by the scale adopted and the maximum distance from the range-finder to the target, and its shape will be determined by that of the protractor-scale. This board or table may be provided with legs, if desired; but for convenience of manipulation and transportation it is ordinarily better to have it in the form of a board or tablet.

Second. The protractor-scale may be made of metal or other suitable material, which is fastened in any preferred manner to the surface of the board. It may conveniently be merely printed upon a sheet of paper or other suitable material and pasted or otherwise attached to the surface of the board.

Third. The sheet of concentric circles, as shown in Fig. 2, is preferably a sheet of paper, which may be beneficially made water-proof. A sheet or plate of metal or any other suitable material upon which the series of circles and the distance designations can be produced may be substituted for the paper.

Fourth. The distance arm or indicator, of metal or other suitable material, pivoted at the center of the protractor-scale and bearing subdivisions and other indicia, as above described, is preferably provided with a metallic plate H, (see Fig. 3,) adapted to be securely attached, as by screws I, to the board A, so as to give firm pivotal connection for the arm. The plate is not essential, however.

The assembling of these parts in the adjustment of the apparatus is as follows: First fasten the pivot-plate H to the board A so that the center of the pivot will be at the center of the protractor-scale. Next, if the protractor-scale is upon a sheet of paper or other such material attach it to the board or table with glue or otherwise in such manner that its center is at the point to be occupied by the center of the pivot. If the protractor-scale is of metal, then it and the plate are usually permanent parts of the board. Indeed, this may be the case if the protractor-scale be produced upon paper or similar material. Next number the graduations of the protractor-scale, which are normally left unnumbered, in such manner as best suits the conditions under which the device is to be used—that is to say, locate the numerical designations of the degrees of arc relative to the range-finder as may be necessary owing to the position of the gun and the extent of its field of fire, so that the sweep of the arm to determine the distance of the target from the gun may be within the range of the protractor-scale without running off the board. Next attach the distance-arm C by its pivot D to the plate H and mark the point upon the table or boark which, as determined by the numbering of the divisions of the protractor-scale and by the adopted scale of distances, which is the scale of the arm, is in the direction and at the distance from the center of the pivot that the gun is from the range-finder, and this point will be the position of the gun. Next adjust and fasten in any preferred manner the sheet of concentric circles G′ upon the board or table in such manner that the common center of these circles will be at the point marked as the position of the gun, as last above explained, cutting away and removing all portions of the concentric-circle sheet that overlap the protractor-scale. The device is then ready for use, an illustration of which will be as follows, reference being had to Fig. 3 and to the dotted lines, &c., produced thereon: Assume that the gun, relative to the range-finder, has the position azimuth x degrees and distance a yards and that the field of fire of the gun lies wholly or in great part upon the right of the line joining the range-finder and gun. Starting with the board, protractor-scale, and arm assembled, but with the graduations of the protractor-scale still unnumbered, the conditions above assumed require that the center of the concentric circles shall be approximately at K′, whose azimuth from the range-finder is approximately x degrees and whose distance from the same point is approximately a yards. Move the distance-arm until its fiducial edge passes through the point thus approximately determined and number the graduations of the protractor-scale lying nearest to the fiducial edge of the arm to read x (whole) degrees. The other graduations are then numbered from this one increasingly in the direction of the movement of the hands of a watch. Set the arm so that the reading of the protractor-scale is the direction in degrees and minutes of the gun from the range-finder and mark upon the board the point K, which as determined by the reading of the arm-scale has the distance of the gun from the range-finder. This point so marked determines the position of the common center of the concentric circles, and the sheet bearing these circles is then attached to the board, as above described. Assume that the target as observed from the range-finder has the direction y degrees and distance 9 is at the point M, Fig. 3. The distance, therefore, of this point M or the range from the gun, as determined by the subdivision (in this case estimated) of the concentric circle passing through or near this point, is eight thousand eight hundred and seventy-five, approximately.

The use of the protractor-scale and the sheet or plate of concentric circles and the fact that the divisions of the protractor-scale are left unnumbered render it possible and convenient in the assembling and adjustment of the parts to adapt the device to the circumstances of distance and direction obtaining at any desired point of use.

It will be obvious to those who are familiar with this art that modifications may be made in the details of construction and adaptation of the parts without departing from the essentials of the invention. I therefore do not limit myself to such details.

Having described my invention, I claim—

1. In a replotting apparatus the combination of a table or board provided with a protractor-scale, a distance-arm pivoted thereto and subdivided according to any suitable scale and adapted to coact with said protractor-scale, and a sheet or plate carrying a series of concentric circles, which is spread upon the table and the center of which is adjustable relative to the center of the protractor-scale whereby it is adapted to coact with said scale and said arm, for the purposes set forth.

2. For use in conjunction with a protractor-scale and distance-arm, a sheet or plate of suitable material carrying a series of concentric circles spaced and numbered so as to indicate distance in accordance with the scale of the distance-arm, as set forth.

3. A replotting apparatus embodying a board or table, a protractor-scale produced thereon, a distance-arm concentrically pivoted to the board or table relative to the protractor-scale, a sheet or plate of suitable material which is spread upon the table and which is adjustable relative to the center of the

protractor-scale and carrying a series of concentric circles, said circles being spaced and numbered to coincide with the scale of the said arm, for the purposes set forth.

Signed at New York, in the county of New York and State of New York, this 8th day of August, 1900.

CHAS. L. PHILLIPS.

Witnesses:
Phillips Abbott,
William H. Snelling.

DESCRIPTION.

The principal parts of this instrument are: a semi-circular plotting board or base having an exterior radius of about twenty-three (23) inches; a metal protractor scale covering about two hundred and ten (210) degrees and graduated, diagonally, to read degrees; a distance arm, pivoted at the center of the protractor and graduated to read thousands of yards to include ten thousand (10.000) yards; a subscale, attached to the outer end of the distance arm and graduated to read subdivisions of the degree graduations of the protractor, least reading two (2) minutes; a sliding subscale, working on the distance arm and graduated (*a*) upon the upper side, to read subdivisions of the thousand yards graduations of the distance arm, least reading twenty (20) yards, and (*b*) upon the fiducial edge, to read subdivisions of the distance graduations of the plotting sheet, least reading twenty (20) yards; a gun arm, also pivoted at the center of the protractor, graduated to read, with its slide, tens of yards to include one thousand five hundred (1,500) yards, and having attached to the slide a cord used in connection with the plotting sheet protractor; and a lithographed plotting sheet carrying a numbered series of equi-spaced concentric circles and a protractor scale graduated diagonally to read degrees, and, by a series of equi-spaced concentric arcs to read five (5) minutes.

This plotting sheet is the new and principal feature of this class of instruments and differentiates it from all others. It furnishes the means whereby the instrument may be adjusted to the position of the gun relative to the P. F. for any azimuth, and for any distance between gun and P. F. to include one thousand five hundred (1,500) yards.

A celluloid strip attached to the board outside of the metal protractor permits the numbering of the protractor graduations in accordance with existing conditions.

The subscale at the outer end of the distance arm is attached to the arm by a clamping thum-screw and has a slight adjusting movement to compensate for any expansion or contraction of the protractor.

The protractor is attached to the board by clamping thumb-screws entering it from the under side and provided with slotted bearings so as to permit a possible expansion or contraction of the board to take place without causing a distortion of the protractor.

The thumb-screw which forms the common pivot of the distance and gun arms is so arranged that it will clamp the gun arm in position without interfering with the free movement of the distance arm. It is also fitted with a prick-point to be used for adjustment purposes as described below.

The scale of the instrument for all linear measurements is five hundred (500) yards to the inch. The radial spaces between adjacent concentric circles in the plotting sheet represent each five hundred (500) yards and the numbers on these circles indicate distances in yards from their common center.

ASSEMBLING AND ADJUSTING.

In order that the entire field of fire of the gun may be contained within the limits of the board the plotting sheet should be so prepared that when in position on the board the axial line of the field of fire will be approximately parallel to the axial line of the board. The record of the orientation of the post will give the azimuth of this axial line of the field of fire. Write, radially, the number indicating the whole degrees of this azimuth opposite that graduation of each of the protractors that is nearest to the axial line of the board and plotting sheet respectively, upon the celluloid strip for the metal protractor and just outside of the outer line for the plotting sheet protractor, and from these points complete the numbering of each protractor in both directions. Upon the plotting sheet protractor mark the point which reads the azimuth of the gun from the P. F., and through this point and the indicated center of the concentric circles draw with a pencil a straight line prolonging it beyond the center a distance, according to scale, equal to the distance of the gun from the P. F. Lay oft this distance on this prolongation from the center and the point so determined marks the position of the P. F. on the plotting sheet. With this point as a center and with a radius about one-half an inch greater than the inner radius of the metal protractor, describe upon the sheet, with a string and pencil, a circle and cut the sheet along this circle. By means of its thumb screws raise the protractor slightly above the surface of the board and insert the pivot thumb-screw in its socket from below so that the prick-point projects slightly above the upper surface of the board. Adjust the slide of the gun arm so that its reading is the distance of the gun from the P. F. Place the plotting sheet in its approximately proper azimuthal position upon the board so that the prick-point pierces it at the point determined as the position of the P. F., at the same time slipping the edge of the sheet under the protractor; holding the sheet in position with one hand, remove the pivot thumb-screw from below and passing the prick-point from above through the hole punctured by it in the sheet, give it a turn or two in its socket, thus cutting out a small disc from the sheet and fitting it to the pivot. Remove the pivot thumb-screw and clear the socket of this piece so cut out and then assemble the gun arm, distance arm and pivot, taking care not to clamp the gun arm. Using the zero graduation of the protractor subscale at the end of the distance arm as a pointer, adjust the protractor to concentricity with the pivot; move the distance arm slide to near the outer extremity of the arm and set the arm to read the azimuth of the gun from the P. F.; turn the plotting sheet about the pivot until the pencil line previously drawn thereon is coincident with the fiducial edge of the distance arm slide; clamp the protractor down upon the sheet.

Turn the gun arm about the pivot until the pointer at its outer extremity lies over the pencil line above described and, by turning the pivot thumb-screw, clamp it in this position. This completes the adjustment and the instrument is now ready for use.

Diagramatically, the center of the metal protractor or pivot of the distance arm represents in this instrument the position of the P. F.; the common center of the concentric circles on the plotting sheet when this sheet is properly adjusted represents the position of the gun; setting the distance arm so that the protractor subscale reads the determined azimuth of the target of the P. F., and the slide on the arm so that the upper scale reads its distance, the zero graduation on the fiducial edge of the slide fixes the position of the target. The number on the concentric circle next nearer to the center from this zero point plus the reading of this scale is the range, and the reading of the protractor scale on the plotting sheet when the cord is stretched across it and over the point is the azimuth of the target from the gun. The method of use of the instrument is evident.

The following features may be advantageously added in the preparation of the sheet.

1st. Hydrographic lines properly oriented with reference to the P. F. and showing shoals, channels, &c., within the field of fire.

2d. Radial lines from the indicated center of the sheet showing the limits of the field of fire.

3d. Arcs within these bounding lines showing zones within which a certain character of projectile would, under conditions of service, be appropriate.

The plotting sheet being of paper the representation of these lines in different colored inks is readily made, and also permits the board to be used in plotting the successive positions of the moving target, tracking vessels, predicting positions of target, &c.

Aids in Predicted Firing.

In predicted firing, it is almost too much to expect that a target will not only come to the predicted point but that it will also arrive there at the instant predicted. Even if the target should meet these conditions, the system requires unnecessary accuracy in selecting the predicted point and a noting of time intervals.

In what may be called the Set-back System it is sufficient if the target come to any point in the predicted course taken far enough in advance of the last observed position to insure time for laying the gun, and if the target, simply during the flight of the projectile, keep approximately the speed indicated by the observation.

When the probable course of the target and a predicted point have been selected, what is known as the set-back point is a point in the probable course short of the predicted point a distance equal to that which the target will travel during the time of flight of the projectile.

An observation on the set-back point enables the battery commander to see exactly when the target is in such a position that the command "fire" should be given, or whether it has changed its course enough so the fire should be held and a new predicted point selected.

The set-back distance is equal to the time of flight in seconds multiplied by the speed of the target in yards yer second.

A simple chart for determining this distance for any speed of target, within assumed limits, and any range for any particular caliber of gun, may be made as follows:

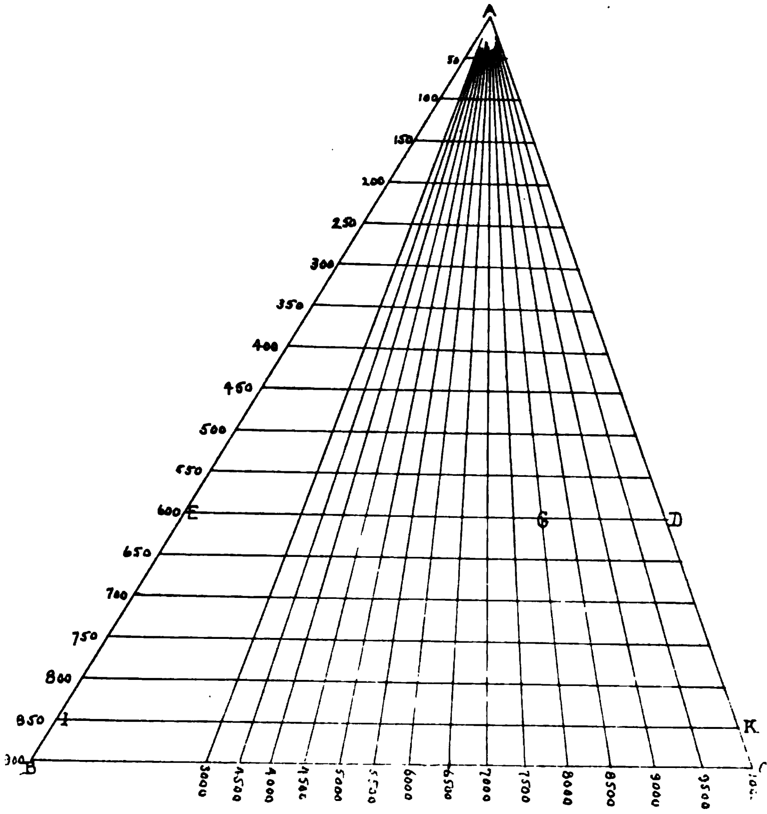
See fig. 1. With a fine pointed pencil, draw *B C*, making it equal to the maximum set-back expected, to a scale such that it could be easily read if graduated to 10 yards. Let *B C* represent the time of flight for the case considered,—that is for maximum range and maximum speed.

This being assumed lay off on *B C* the time of flight for every 500 yards from 3000 yards to the maximum range, and mark the points so determined with the numbers which indicate the ranges to which these times of flight pertain.

Draw *B A* so that it shall be somewhat longer than *B C* and so that *A* shall be approximately over the center of the scaled portion of *B C*. Mark *B* with the assumed maximum speed of target and divide *A B* so as to have 50 yards as the smallest division. Mark these points of division with the proper figures to show the speed per minute. Draw right lines connecting *A* with the points marked on *B C*, thus making range lines.

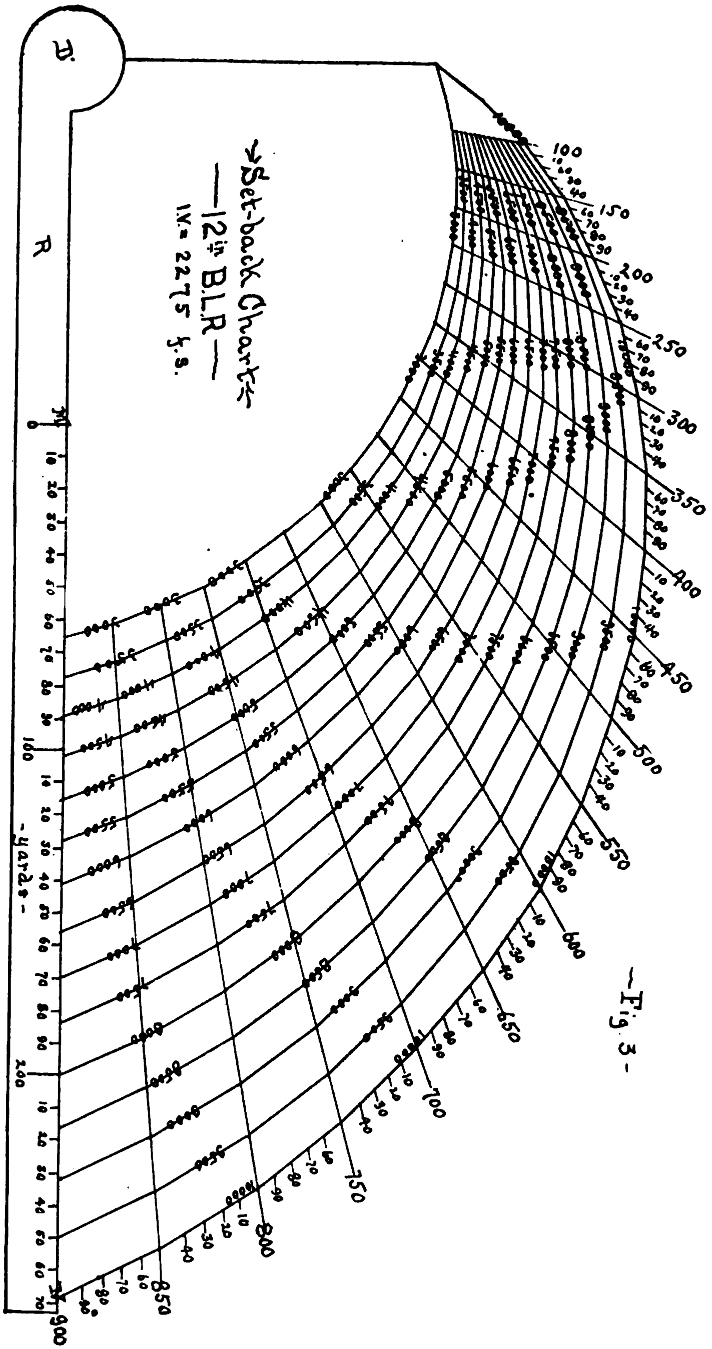
Through the points on *A B* draw the speed lines parallel to *B C*, producing them till they cut *A C*.

By drawing the figure as explained we obtain the intersection of range and speed lines.

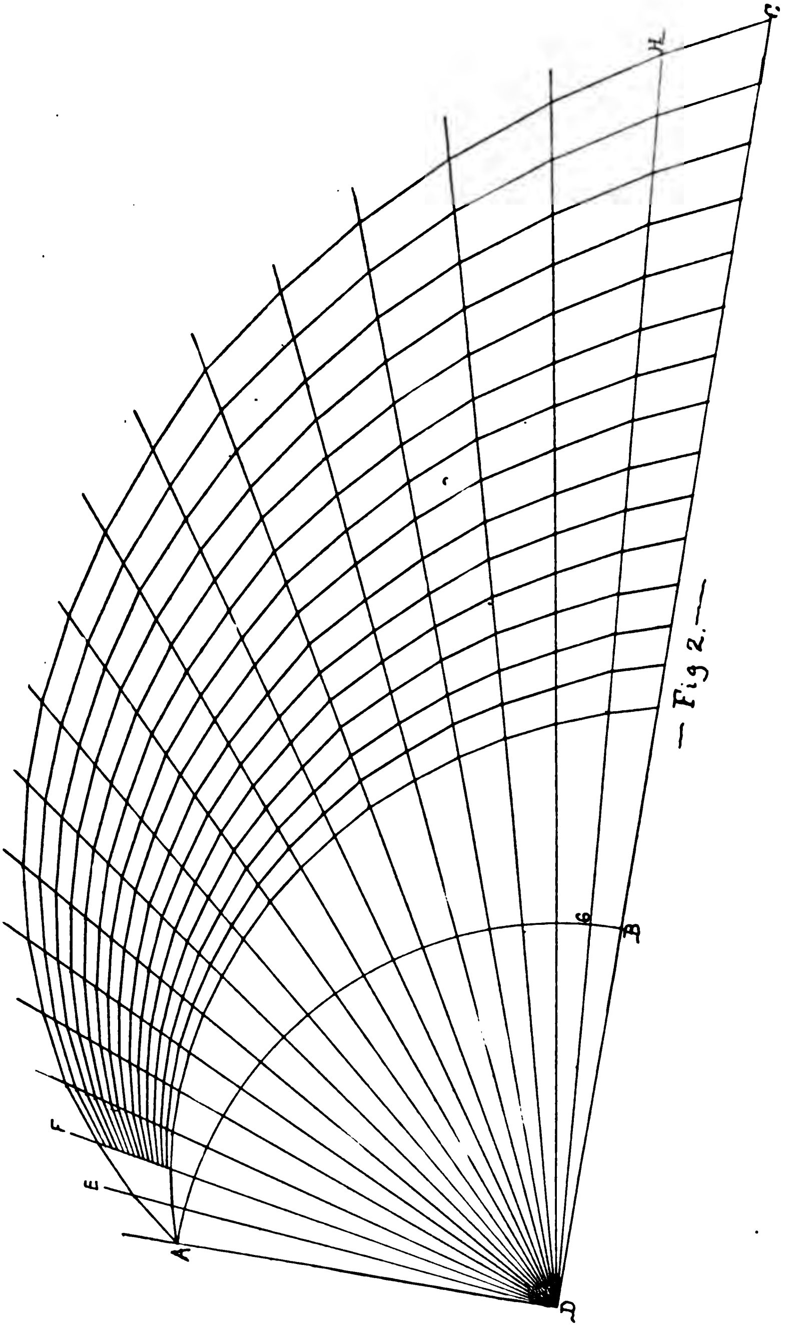


—Fig. 1.—

An examination of the figure shows that *B C* must be the set-back when the range is the maximum (say 10000 yards) and the speed the maximum (say 900 yards); and that, the speed remaining the same, the set-back for any other range is that portion of *B C* between *B* and the indicated range line. This is true because with the same speed the set-back varies directly as the times of flight. Taking any other speed as 600 yards, then *E D* is the set-back for the maximum range: for in this case, the times of flight being equal, the set-back varies as the speed, and we have similar triangles so that *B C* is to *E D* as *A B* is to *A E*.


D
R
Set-back Chart
— 12 pr B.L.R. —
I.V. = 2275 f.s.
- yards -
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900

— Fig. 3 —



— Fig 2. —

The set-back for speed 600, range 8000, is seen to be *E G*. So for any speed and range the set-back is that portion of the indicated speed line between *A B* and the indicated range line.

This figure, with the aid of a proper scale, can be used to read set-backs, but it has been found more convenient to change the figure to one in which polar co-ordinates are used.

To do this—draw *D C* (see fig. 2) so that *B C* shall equal *B C* in fig. 1, and *D B* shall be say ½ *B C*. Draw the circular arc *A B* and lay off on it from *B*, as many equal small arcs as there are spaces between the speed lines in fig. 1, making the angle *A D B* not greater than 90°. Through *D* and the points of division on *A B* draw radial right lines *D C*, *D A*, *D E*, *D F*, etc. *B C* of this figure has been made equal to *B C* of fig 1; now lay off on it the same divisions as on *B C* fig. 1. Lay off *G H* equal to *I K* of fig. 1 and set off upon it the same divisions as are formed on *I K* by the range lines.

And so on till each speed line has been reproduced in fig. 2 with its proper points of division. Draw a regular curved line connecting all the speed line points of division farthest from *D*,—this will be a reproduction of the range line *A G*.

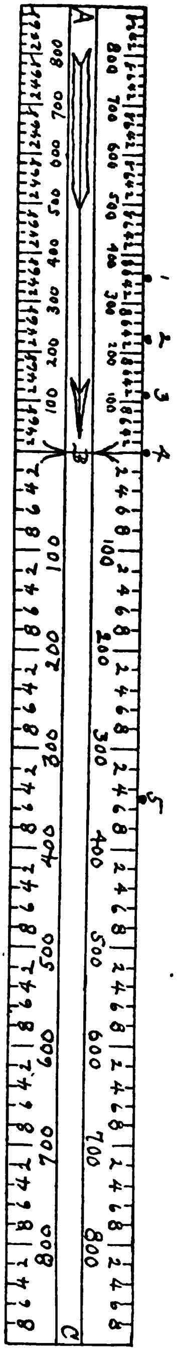
Similarly reproduce the other range lines. The chart will be sufficiently accurate if, instead of drawing curves, the various successive points of each curve be connected with short right lines.

Ink the essential lines of the chart (see fig. 3) and erase pencil lines, mark each range line in several places and each speed line once at its outer end. Graduate the spaces between outer extremities of the speed lines so that readings may be had for every ten yards. It is advantageous to draw and mark the range lines in black and the speed lines in red.

Prepare a small ruler (R fig. 3) to pivot at *D*, having a fiducial edge which produced would pass through *D*. *D M* must equal *D B* of fig. 2, and *M N* must equal *B C* of fig. 2. *M N* then equals the maximum set-back and the reading at *N* must be that value.

Graduate and mark *M N* to read to ten yards as the smallest reading. Secure the ruler by passing along pin or brad through *D* and the point on the finished chart corresponding to *D* of fig. 2, and the chart is ready for use.

In order to use the above, the ruler or apparatus used in predicting must give the speed of the target. A suitable ruler is described below and is shown in fig. 4, which shows the ruler placed on a plotting board in positionfor making a prediction.



— Fig. 4 —

A light wood ruler with both edges beveled has been found convenient. The portion *A B* is made to read the same as the ruler on the plotting board and is of the same scale.

The portion *B C* has its scale twice, three times, or four times that of *A B* according as the predictions are to be approximately two, three, or four minutes ahead of the last observation. To use—let 1, 2, 3 and 4 be four plotted observed positions of the target. taken at 20 seconds intervals; then the speed is read at once from the scale 350, and the predicted point found by marking the point 5 at 350 on the scale *B C*.

To use the set-back chart—move its ruler to the speed line marked 350, and as soon as the range from the gun to the predicted point is announced, note where the indicated range line strikes the edge of the ruler and read the set-back from that point of the scale on the ruler. By means of that portion of the scale of the predicted ruler marked *A B*, the position of the set-back point is easily plotted and then its range and azimuth can be given so that the observing instrument or instruments can be laid on it, and the command "fire" be given when the target reaches it.

In preparing a chart for use in mortar firing, instead of laying off on *B C*, fig. 1, the times of flight for different ranges and marking the points for range, lay off points for every ten seconds of time of flight and mark the points for time of flight, then proceed as with chart for guns.

In using the resulting chart the arguments will be speed and time of flight instead of speed and range.

The foregoing are but modifications of the set back chart and auxiliary scale prepared by Major Whistler, U. S. Artillery Corps; but it is thought possible that they may be found to possess some peculiar advantages.

NOTE.—The reason for making *A B* equal to say ½ *B C* in fig. 2 is that it keeps the range lines from making two acute angles with the speed lines.

The angle between *A D* and *A C* should not be any greater than is necessary to insure sufficiently large spaces between speed lines, for if too great, the chart is spread over more surface than is necessary and is not so conveniently read.

GEO. W. GATEHELL,
Captain U. S. Artillery Corps.

WARSHIPS AND TORPEDO BOATS.

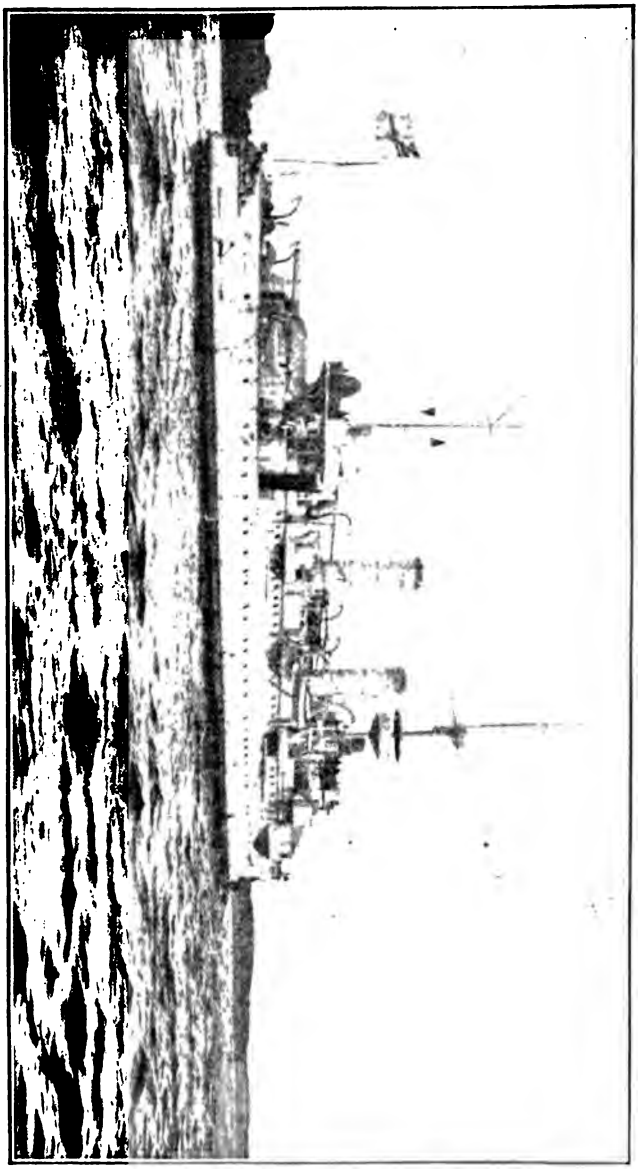
Modifications of the German Ironclad *Hagen*.

(Negatives furnished by the *Armee und Marine*, Berlin.)

With the inauguration of the movement to increase the German fleet by building new vessels arose the idea of turning the old hulls to account by modernizing them.

In this the Germans have but followed the example set them by other maritime powers. They have exhibited, however, much greater originalty and enterprise in this direction than have their rivals. Not content with modifying the boilers and engines, with replacing the old guns by lighter and more powerful pieces and with utilizing the saving in weight thus realized to increase the protection, the have also decided to increase the tonnage of a whole class of vessels by increasing the length of their hulls by several meters.

The vessels comprised in the category just mentioned are eight in number, as follows: *Hagen*, *Beowulf*, *Frithjof*, *Heimdall*, *Hildebrand*, *Siegfried*, *Aegir* and *Ödin*. They are armored coast-defense vessels, the plans of which were drawn up at a time when the defensive was still one of the preoccupations of the German Navy. As a consequence these vessels, designed to move along the coast and hence ever near their points of support, needed but a slight coal supply, the amount of the latter being 220 tons. Their displacement was made as small as was compatable with obtaining the combination of qualities deemed indispensible to the type it was endeavored to create. Once in service, the armored coast-defense vessels gave entire satisfaction; they exhibited very remarkable nautical qualities and it was even decided to increase



The *Hagen* (after Alteration).

their number from the six already built to eight. The last two were given a slightly greater displacement, the latter being utilized to procure a greater engine power and greater coal capacity.

The moment, however, that the emperor began to turn his eyes towards the sea with a view to making a maritime power of Germany, that moment these vessels ceased to longer satisfy his ambition. The defensive is no longer admissible and although the sovereign disclaims all thought of aggression in his projects for increasing the fleet, it is nevertheless clear that he looks upon the offensive as the best tactical defensive.

In view of this change of ideas the coast defense vessels of the *Siegfried* type could not be considered as a valuable addition to the new fleet. Still they were not wholly without value for, aside from their totally inadequate radius of action, their other qualities were such as would have entitled them to be classed as a good type of sea going battleships. It was therefore necessary to remedy this defect and this was accomplished by increasing their coal capacily, the result being that at a relatively low cost, good vessels were obtained which are still modern seeing that the oldest date no farther back than 1889.

In order that the coal capacity might be increased it was necessary to increase the displacement and hence also the length of the vessel.

This work, which is quite simple for a ship of commerce, as, for instance, a passenger steamship, is not free from certain difficulties for a battleship of even such small tonnage as that presented by those of the *Siegfried* type. In order to lengthen the vessel it must first be cut in two and the halves separated the requite amount, then a midsection is added of such displacement as will bring the tonnage of the modified vessel to that desired. Now in order that the operation may be economically conducted it is essential that as few items as possible be moved from the parts of the vessel which are to remain intact; hence the armor, turrets, engines and boilers must be left in place, and as these objects are very heavy, the maneuvring of the parts of the vessel is rendered very delicate.

Before subjecting all the vessels of the class to these modifications it was thought advisable to first try the experiment upon one of them with a view to determining from the trials of the latter whether such modifications yield advantages commensurate with the outlay. The *Hagen* was selected for this purpose. In September, 1899, it was placed in one of the graving docks of Kiel. A section was made just in front of the engines and the inner part moved back a distance of 8.4 meters. The operation which consisted in moving a mass weighing from 1400 to 1500 tons only lasted about one hour. The armor, the rear turret and the entire engine were left intact. The mid section to be added represented a weight of from 500 to 600 tons.

The trial of the *Hagen* took place in October 1900, about one year after the operation was begun, and proved highly successful. The engines and boilers behaved perfectly. The indicated horse power was 5235, giving about 142 revolutions per minute.

The increase in the coal supply from 220 to 500 tons resulting from the increase in the displacement, taken in connection with certain other improvements, have changed this coast defense vessel to a true battleship, not of the first rank, it is true, but still to one capable of being turned to good account.

The good results thus obtained leave no doubt that the next budget will make provisions for the modification of the other seven vessels of this class. It has been estimated that the total sum necessary to change the eight coast defense vessels will be about 25 million francs, that is to say, the price of a single modern battleship. It is not difficult to determine the advantages of these modifications to the German fleet, and while we are not, as a general rule, in favor of charges which are very costly and add but little to the vessels selected for improvement, we are forced to admit that, in the present instance, the German Admiralty has been well inspired.

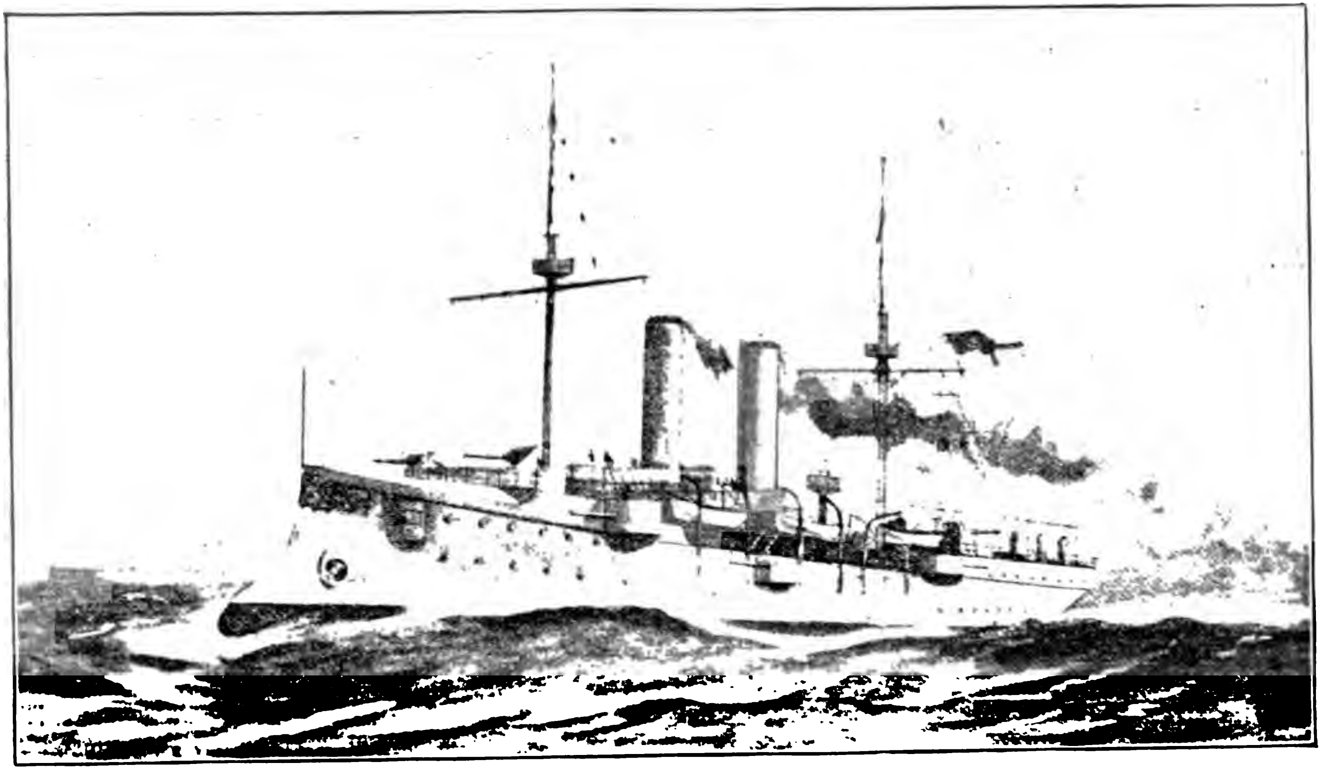
Translated by Captain Frank E. Harris, Artillery Corps, U. S. Army.

German Battleship, *Wittelsbach*.

Germany, more even than we are, is convinced that battleship fleets should be homogeneous. So much so is this the case, that though paper sacrifices have been made to remedy the worst defects of the *Kaiser Freidrich III* class, the original standard ship, other defects have been repeated.

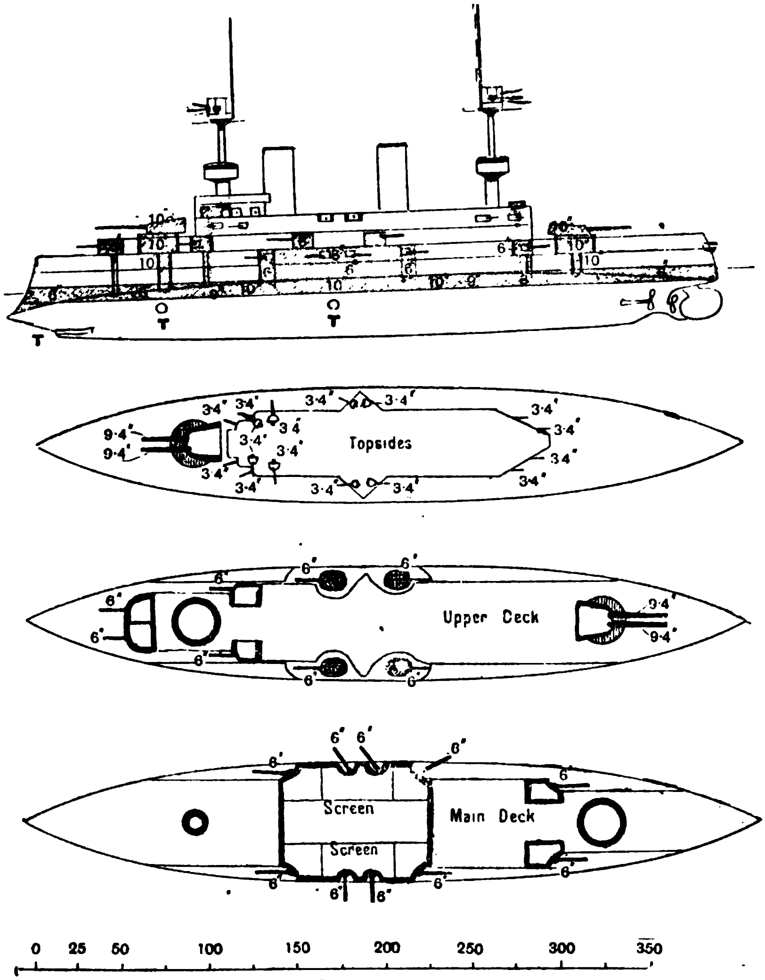
The *Kaiser Friedrich* is a well-known ship, and though no single plan published of her in England is absolutely correct, the error is confined to a single particular. We refer to the big guns. In the *Naval Annual* and in all other annuals these are shown as turrets, without armored bases. This is incorrect; the real mounting is exactly like that in the *Wittelsbach*, *Fürst Bismark*, &c., that is to say, a barbette, with a hooded shield above it. This makes the *Kaiser Friedrich* a much better ship than she looks on paper; but the main defect, the mounting of the 6-inch guns at a great height, with no protection to their bases other than the armored hoists, remains. It is the penalty that accompanies the advantages of a lofty gun position. We tremble to think of the effect of a big shell bursting underneath all that nest of artillery. In the *Wittelsbach* this—the great defect of the *Kaiser Friedrich III.*—is remedied, and much of the lofty altitude sacrificed.

Another defect of the *Kaiser Friedrich* is the very ingenious end-on fire. It is exactly the sort of thing that various well-meaning landsmen critics have called for here. It is essentially pretty, and also essentially non-nautical, for it is marred by certain hard facts. For instance, when a gun is fired, it does something more than project a shell. It also projects a volume of flame and a concussion known as the blast. Even from a 12-pounder the blast is such that anyone at an open port-hole underneath is buffeted by it. Were he in the act of firing with rapid aim through that port-hole, he would be as likely to hit the moon as the object aimed at. Now a six-inch gun, instead of a charge of about 12 pounds of cordite or other modern powder, will have a charge of about double that amount, and a blast considerably more than double. A big gun, again, has an enormous blast, out of all proportions to the relative increase in size. The German 9.4 may be as bad as the 110-ton gun, the blast of which in the *Sanspareil* once stove in a deck and killed a man sleeping below, and on another occasion wrenched away much solid metal; but if a man stood directly below it when fired, the collection of enough charred remains to justify an inquest would entail considerable difficulty. Inside a casemate he is, of course, largely protected from the concussion, but the back fire can still get at him through the port. In our *Majestic* class we have found that 12-pounders under the big guns cannot be manned without grave risk of accident when the big guns fire on the beam. Now, wherever the big bow guns of the *Kaiser Friedrich III* fire, it seems to us that they must drive a back fire into a casemate packed just below them. In the *Wittelsbach* this same defect exists. Of the eight 6-inch, two 9.4-inch, and six 3.4-inch that can theoretically be fired right ahead, and make, on



German Battleship *Wittelsbach.*

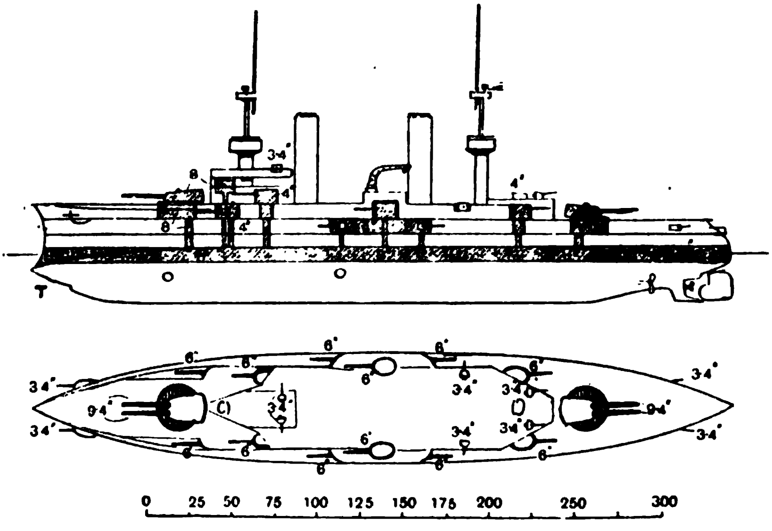
paper, such a fine "energy of fire," we believe only a fraction could actually be employed. Similarly, aft in the *Kaiser Friedrich*—this defect is remedied in the *Wittelsbach*—two 6-inch have muzzles nearly touching the sighting hoods of the after big gun turret, two more 6-inch and some 3.4-inch fire more or less over it, and two other 6-inch send a blast on either side to swell the total. This means a constant volume of flame and heat, to say nothing of the noise and smoke—for smokeless powder is not absolutely smokeless—around the man sighting the 9.4-inch. Will he or his eyes survive it, and if he does, where will his projectiles go? This thing the Germans will look to have realized, for the *Wittelsbach*—as an inspection of the plan will show—is free from this defect. But the minor edition of it forward remains. The mere expectation of blast will ruin any man's nerve; indeed, anticipation is worse often than reality.



THE WITTELSBACH

It may, of course, be argued that there still remains a very fine arc of fire to each gun, and to some extent this is true, but only to some extent. In the *Kaiser Friedrich* there is "interference" all round save on the broadside; and one has only to compare her with any new French ship—in French ships the end-on fire is quite as eagerly sought—to see how much more practicable are our neighbors across the channel than the Germans. In the *Wittelsbach* a leaf is taken out of the French book to a considerable extent.

Yet another peculiarity of both German types we cannot feel our ground enough to set down as a defect. We refer to the big guns, which are 9.4-inch only. Every other nation has adopted the 12-inch. The 9.4-inch has very good penetration, but it is absolutely useless against a modern belt or turret. On the other hand—so greatly has armor improved—the 12-inch is equally useless at anything over 2000 yards. More, no 12-inch in existence could get to the engines of most modern ships, save at very close range indeed. The battle of the future will, therefore, see more and more reliance placed on shell. Presumably the German argument is that chances to use shot will rarely occur; that a big shell between the big guns will put them out of action as surely as a shot, while as a 9.4 will fire rather quicker than a 12-inch, it is more likely to hit.



THE FURST BISMARK

All this may be true. The only thing is that the same reasoning applies to an 8-inch, or even a 6-inch, for in a given time most guns discharge shell doing equal damage: it is a choice between many small and few big. The few big, however—so experience has shown—do a damage quite disproportionate to their size. An 8-inch shell of 200 pounds will burst far more destructively than two, or even three, 6-inch of 100 pounds each. Presumably there is virtue in the concentrated blow. If all this reasoning is followed, all that remains is to select a gun that gives the best mean result, and presumably the Germans favor the 9,4 as a big shell gun, for much the same reason as other nations have selected the 12-inch in preference to the 13.5-inch or 16-inch, once more powerful than the 12-inch, and which would certainly be infinitely more powerful if of modern make.

A 16-inch, on the lines of a 12-inch, Mark IX., would get through the thickest armor at almost any range—for that matter, a new 13.5-inch probably would. As things stand, and thinking only of ships now completing or building, the question whittles down to this. A 9.2-inch frankly disclaims any armor-piercing ability; the 12-inch is impotent against turrets or vitals at most ranges, but in most cases it can drive in portions of the water-line amidships. Can these holes be plugged, if made?[*] Are they at all likely to be made? The selection of the heavier or the lighter gun really turns on little but that. Handiness, and so on, does not enter, for the 12-inch IX. is as much a quick-firer as the 9.4-inch, and quite as easily managed. It is not even certain that its rate of fire is less. It is, to be sure, a good deal heavier, so that weight saved on the lighter guns can go in extra 6-inch, and such like, but that is about all.

Particulars of the *Wittelsbach* are as follows:—

Displacement	12,000 tons.
Length	377 feet.
Beam	67 feet.
Draught	28 feet.
Guns—Primary	Four 9.4-inch in 10-inch barbettes and cupolas.
Secondary	Eight 6-inch in a 6-inch battery. Four 6-inch in turrets (6-inch). Four 6-inch in casemates (6-inch).
Tertiary	Sixteen 3.4-inch (20-pounders). Twelve 1-pounders. Eight machine guns.
Torpedo	Five submerged tubes (one of them in the bow).
Horse-power	15,000.
Speed	19 knots.
Screws	Three.
Boilers	Thornycroft (Schültz).
Coal capacity	About 1200 tons.

The armor is all Krupp system. In addition to that noted above, there is a belt 10 inches or 9 inches thick amidships, reinforced by a protective deck 3 inches thick, and by coal protection. At the ends the belt goes down to 6 inches. In British ships 2 inches or 3 inches is held to suffice.

Amidships there is a 6-inch redoubt, above which is the battery, and above again turrets, all 6 inches in thickness. The battery ports are indented so as to give a wide angle of fire. The 3.4-inch guns, it will be noted, are grouped in pairs; and it is characteristic of the ship that there are plenty of spaces without guns in them. German design, hitherto, has exhibited a marvelous fancy for guns all over the ship and in every possible place. Other details are sufficiently obvious from our illustrations.

The accompanying diagram shows the arcs of fire of various guns, and the number that train on any given point. The fire before the beam is, it will be noted, better than the fire astern, which is presumably an indication that Germany expects to attack in the future. French ships exhibit a tendency

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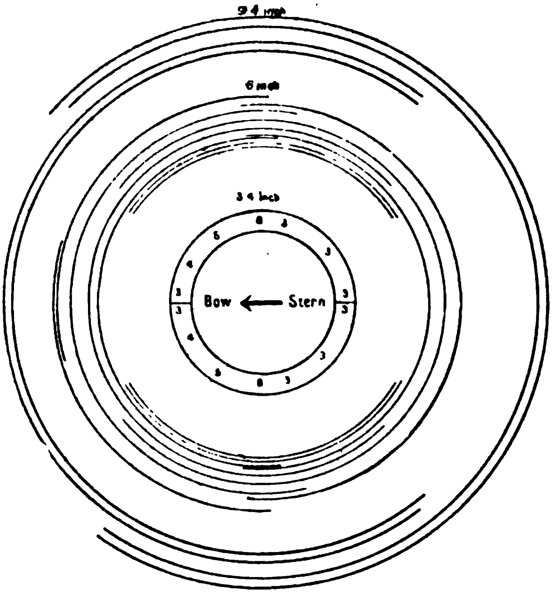
[*] A 12-inch entry hole becomes anything from 3 feet to 10 feet at exit. The piece driven before the shot splits up, and would tear to pieces any bunker walls or any cofferdam that it touched.



in the opposite direction, and French tactics trend to those of a "runaway" order. By this we do not mean flight; but a determination to make use of such facts as that it is easier to shoot straight if you are firing astern. The difference if not very much, but coupled with other differences alluded to above, is a tolerably clear indication that a brighter intellect is the *deus ex machina* in French designs than in German. The assumption is, too, that it is carried into details of the sort that one does not hear about. French ships look very bad on paper in certain respects, and there is a great tendency over here to decry many things that are essentially French in design; but we are bound to admit that if one carefully and honestly examines any characteristically French thing, a reason is always to be found at the bottom of it. In German ships there are few signs of this careful reasoning, though it is what one would expect to find. This is curious enough to be noteworthy.

What, for want of a better term, we may call the evolution of the *Wittelsbach* class is of some interest. The germ-idea is to be found in the *Fürst Bismark*, which is by way of being an alternative design to the *Kaiser Friedrich*. She is called an armored cruiser, but cannot be so regarded. Her armor is a little thinner than that of the *Kaiser Friedrich*, and she carries twelve instead of eighteen 6-inch guns, in revenge for which—as the French phrase runs—she has a little more speed. Now, in the *Fürst Bismark* we find the 6-inch armored battery topped by turrets, and other guns in casemates or turrets, well away.

In the modified *Fürst Bismark*, the *Prinz Heinrich*—a vessel with which *The Engineer* dealt at length not long since—we find armor placed under the battery, and the battery grown in importance. In the *Wittelsbach* precisely the same idea is visible, only still more guns go to the central group.

Whether the Germans have really reached their standard, as they imagine, is another matter. Probably it is a temporary one only; the *Kaiser Friedrich*

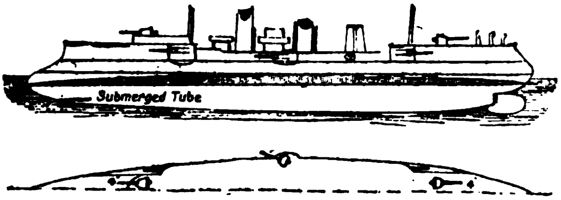
III. used to occupy this position, but she has not held it long. However, for the present, no new German ships are to deviate from the *Wittelsbach* design.
—*The Engineer*, December 28, 1900.

The New German Cruiser *Amazone*.

The *Amazone* is a third-class cruiser of the vedette sort, equivalent to our own *Pelorus* class. She is spoken of and to some extent is an improved *Gefion*, but as the following particulars show, she resembles the prototype in little save armament:

	Gefion.	*Amazone.*
Displacement, tons	4207	2645
Length, feet	334	328
Beam, feet	42½	39
Draught, feet	21½	16⅓
Armor deck, amidship	3 in.	2 in.
" ends	1 in.	1 in.
Armament	Ten 4 in., six 6-pdr., eight machine.	Ten 4 in , ten 3-pdr. eight machine.
Torpedo tubes	Two above water.	One submerged, two above water.
Horse-power, maximum	9828	6600
Speed (maximum), knots	20.5	20
Coal (normal), tons	900	300

The *Gefion* was launched in 1893; it is interesting, therefore to note that German ideas, which in the *Gefion* closely followed ours, have since then branched off in an entirely independent direction. In the *Gefion* coal is the chief consideration, and the guns are secondary. In the *Amazone* it is just the other way about. The most she can carry is 500 tons.



However, before discussing the ship at length, it may be interesting to compare her with our similar ships, the *Pelorus* class. In the connection the Russian *Novik* may also be introduced, as she represents the same kind of sacrifice as the *Amazone*, only in her case everything is sacrificed for speed:

	Amazone (German).	*Pelorus* (British).	*Novik* (Russian).
Displacement, tons	2645	2135	3000
Length, feet	328	300	361
Beam, feet	39	36½	39½
Draught, feet	16¼	15*	19
Guns	Ten 4 in., ten 3-pdr., eight Maxims.	Eight 4 in eight 3-pdr., three Maxims.	Six 4.7 in., eight 3-pdr.
Torpedo tubes, submerged	1	0	0
" above water	2	2	6
Armor deck, maximum	2 in.	2 in.	2 in.
Horse-power	6600	7000	17,000
Speed (maximum), knots	20	20	25
Coal (normal), tons	300	250	(?)
Coal (full capacity), tons	500	500	(?)

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* 15 feet is the *Pelorus*' nominal draught, but 17 feet is probably nearer the actual. The 19 feet extreme draught to the *Novik* is doubtful.

As the *Pelorus* is a much smaller ship her coal supply is proportionately better, nor does she in any way compare badly with the German. It is worthy of note that the *Pelorus* has 7000 indicated horse-power to make her speed with, while the larger German has to do it with less. Sisters of the *Amazone* have done their 20 knots on trial, but in a race the honors would undoubtedly go to the *Pelorus* class.

To return to describe the *Amazone*. It will be noted that her guns, as in most German types, are placed with a great regard for end-on fire—the theoretical right-ahead fire being four guns, while the amidship pieces have a very large arc. The *Pelorus* has but two guns that fire right ahead. Actually the German fire would not exceed three—cases in which both end sponsons could fire at the same ship being chiefly theoretical.

The *Amazone* is to be fitted with the Schultz boiler, which is an adaptation of the Thornycroft, and resembles it very closely indeed.

The protective deck has a somewhat curious form, various hatchways in it being protected with armored coamings. Amidship, too, the deck, instead of being a mere roof to the engine-room, more or less fits closely upon them, and wherever anything reaches high up the deck is there domed up for it. It is at least ingenious. Altogether about eight ships of the *Amazone* type are built or building. Those launched and completed or nearly so include the *Gazelle*, *Nymphe* and *Niobe*. Another, the *Ariadne*, has just been launched. The remaining three are not named as yet. Others appears to be projected.

—*The Engineer*, November 2, 1900.

BOOK REVIEWS.

The Naval Annual, 1901. Edited by John Leyland. Portsmouth: J. Griffin & Co., 2. The Hard. New York: D. Van Nostrand Co.

This invaluable manual appears once more under the editorship of Mr. Leyland, who undertook the work for Mr. Brassey last year. Our readers are too familiar with this handbook for the navy and the artillery, to require any remarks as to its importance, but we believe it is worthy of even greater consideration at the hands of the government than it has received, and a copy should be supplied annually to every artillery post and every war-ship.

There was a time when its estimates of the value of our own ships was very unsatisfactory to our naval officers, but that is long past, indeed, the complimentary reference to our Navy throughout the text should now satisfy the most exacting.

The usual articles on the progress of the British and of foreign navies, and the tables of comparative strength appear in their old dress, and preserve the reputation of the work. Among the new matter may be mentioned an article by Admiral Hopkins on Fleet Auxiliaries, one by the editor on the Transport Operations to South Africa, and another by Commander Robinson on the Operations of the Naval Forces on Shore in South Africa. Captain Bacon's notes on Naval Strategy are also of special interest.

In discussing comparative strength the editor makes this remark, of special interest to us.

"It may also be pointed out that France and Russia have lost their lead as the great foreign ship-building Powers, and that Germany and the United States are taking their place. Most friendly relations happily exist between Great Britain and these Powers, but it should not, nevertheless, be lost sight of, that, contrasted with their combined strength, our situation does not appear in a light so decidedly favourable, while the vigorous ship-building policy adopted by these powers promises most rapid expansion. As an indication of this promise and of the recent character of the development, it will be instructive to note that while of battleships actually on the stocks or just about to be commenced, we have four, Germany and the United States have six and eight respectively."

As a whole the present volume is in all respects equal to its predecessors, and remains the world's authority on the subject. J. P. W.

Die Principiellen Eigenschaften der Automatischen Feuerwaffen. Eine Studie ueber die neuesten Errungenschaften der Waffentechnik fuer Offiziere aller Waffen von Kaisertreu. Vienna: Wilh. Braumueller & Sohn. 1902. Pp. 140. Price, 3.40 Marks.

The question of automatic fire-arms is definitely before the world, and it is only a question of a very short time when the armies will be armed with automatic small-arms. The work before us is therefore timely, and its comprehensive character makes it particularly valuable.

The author is evidently not only theoretically familiar with the principles of the construction of automatic fire-arms, but has also a thorough practical knowledge. He describes not only the latest improvements in the domain of his subject, but includes considerable material not usually available, and much that is not even generally known.

The work considers first the general characteristics of the repeating small-arm of the future, and then takes up first the pistol or revolver, then the rifle and finally the machine gun. After the discussion of the question as to whether the pistol or revolver is the preferable arm, follows a dissertation on self loading pistols.

The various automatic fire-arms are considered under six classes, three of gas-pressure loaders, and three of recoil loaders, the latter including those of complete, long, and short recoil.

The latter part of the work discusses the proper system of loading automatic arms, the proper firing and ejecting mechanism, and the essential principles of automatic fire-arm construction.

The various systems described are the Browning. Borchardt-Luger, Roth, Mannlicher, Bergmann, Mauser, Schönberger, and Schwarzlose, and many older forms are illustrated and referred to in the text, in setting forth the historical development of the various improvements.

There are fifty-two figures in the text and sixteen large plates of illustrations, so that the work, in respect to clearness and detail, so essential in a technical subject, leaves nothing to be desired. J. P. W.

INDEX TO CURRENT ARTILLERY LITERATURE.

PERIODICALS CITED.

Abbreviations employed in index are added here in brackets.

All the periodicals are preserved in the Artillery School Library, Fort Monroe, Virginia.

ENGLAND.

Aldershot Military Society. *Occasional.*
Aldershot. Copies 6*d each.*

Arms and Explosives. [*Arms and Ex.*] *Monthly.*
Effingham House, Arundel Street, Strand, London, W. C. Per year 7 *s.*

Army and Navy Gazette. [*A. and N. Gaz.*] *Weekly.*
3 *York Street, Covent Garden, London. Per year £*1 12*s* 6*d.*

Canadian ilitary Gazette. [*Can. Gaz.*] *Fortnightly.*
Box 2179 *Montreal, Canada. Per year* $2.00.

The Engineer. [*Eng.*] *Weekly.*
33 *Norfolk Street, Strand, London. Per year £*2 6*d.*

Engineering. [*Eng'ing.*] *Weekly.*
35-36 *Bedford Street, Strand, London, W. C. Per year £*2 6*d.*

Journal of the Royal United Service Institution. [*Jour. R. U.S.I.*] *Monthly.*,
22 *Charing Cross, Whitehall, London, S. W. Per year* 24 *s.*

Journal of the United Service Institution of India. [*Jour. U. S. I. Inida*] *Quarterly.*
Simla, India. Per year $2.50.

Military Mail. [*Mil. Mail.*] *Weekly.*
2, *Amen Corner, E. C., London, England. Per year* 8 *Sh.*, 8 *pence.*

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66 *Russell Square, London.*

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United Service Gazette. [*U. S. Gaz.*] *Weekly.*
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Army and Navy Journal. [*A. and N. J.*] *Weekly.*
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Journal of Electricity. [*Jour. Elec.*] *Monthly.*
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Journal of the U.S. Cavalry Association. [*Jour. U. S. Cavalry*] *Quarterly.*
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Popular Science Monthly. [*Pop. Sc. Mo.*] *Monthly.*
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Popular Mechanism. [*Pop. Mech.*] *Weekly.*
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[*Proc. A. S. Civil Engr's.*] *Monthly.*
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The Spanish War Journal. [*Span. War Jour.*]. *Monthly.*
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Technology Quarterly. [*Tech. Quart.*] *Quarterly.*
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Telephone Magezine, Illustrated, [*Telephone Mag.*] *Monthly.*
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Transactions American Institute of Electrical Engineers.
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Texas Volunteer Guard. [*Tex. Vol. Gd.*]. *Monthly.*
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Western Electrician. [*West. Elec.*] *Weekly.*
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The army of Germany.—**R. Mil.**, Brazil, August.

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The cavalry on the field of battle.—**Cercle**, October 5.

Tactical Problem.—**Cercle**, August 5-November 23.

Rules for Coast Artillery fire.—**Memorial**, August.

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The Initiative.—**R. Cav.,** September.

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Napoleon's campaign in Italy.—**Cientifico M.,** August 15.

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The rivalry at sea between France and England.—**Int. Rev.,** Octeber Supplement 31.

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The capture of the Taku forts.—**Jonr. M. S. I.**, September.

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The estimation of distances.—**Wochenblatt**, October 12.

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The French fleet maneuvers of 1901—**Int Rev.**, October Beih. 22.

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THE POSSIBILITIES OF THE CAMERA OBSCURA AS A RANGE AND POSITION FINDER.

BY CAPTAIN W. P. PENCE, ARTILLERY CORPS.

In the system of fire control laid down in the drill regulations, the range and position finder is one of the most important factors. With the perfection of the loading devices attained in the latest models of guns, carriages and emplacements, the time required to load, aim and fire has been so shortened that the gun now waits on the position finder, thus reversing the the conditions that should obtain in a perfect system. Some device that can shorten the time required to accurately determine the range and azimuth of the target has become imperative. In seeking the attainment of this improvement, it may be stated as a fundamental proposition that any system requiring but one observer at a single station will more fully fulfill the conditions than one requiring two or more observers at as many stations, since this duplication involves an increase of liability to personal error, mistake in selection of target and difficulty of simultaneous observation. Moreover, the time required to transmit, plot and replot, renders such a system inadmissable unless some method be devised to perform these operations mechanically.

On the other hand, a system with a single observer involves the necessity of a limited base-line with a greater relative inaccuracy in results. The advantages of a single observer system, however, are so important that almost all recent efforts to develop new range finders have been directed along that line. The best solution of the problem yet proposed and the one adopted for use in our service, is the Lewis Depression Range Finder with which, therefore, any new system would naturally be compared, in judging of its merits.

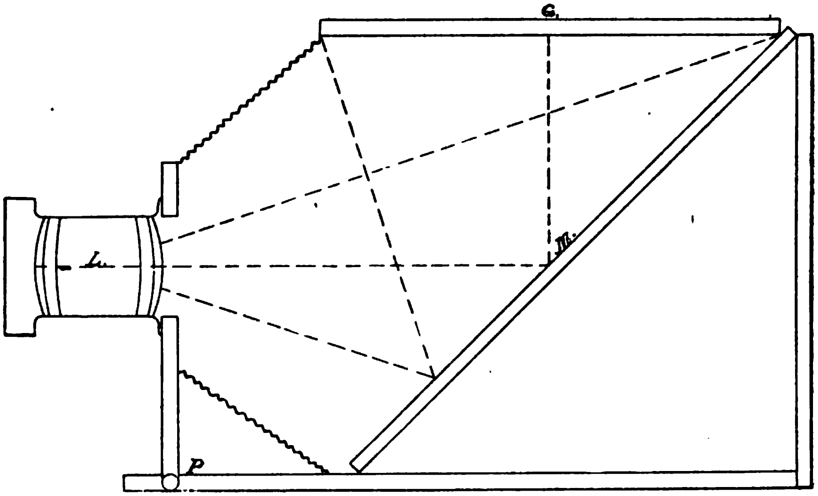
A proposed range finder should correct or modify the following defects in the Lewis Range Finder: 1st. The fact that it must be at least 60 feet above the water to give accurate results, thus rendering it unsuitable for low sites, such as exist at all points south of New York; 2nd. The very limited field of view, taking in not more than the water line of one vessel at a time and giving nothing in the way of a general view of the sphere of action; 3rd. The existence of numerous wheels and gears which wear and lose their adjustment; 4th. The necessity for careful manipulation in order that accurate results may be obtained and 5th. Parallax.

It is the purpose of this paper to investigate the possibilities of the camera obscura as a range and position finder.

The general idea was presented to the Board of Ordnance and Fortification about 1891 by Captain Riché, Engineer Corps, but was not put into a definite form nor given a practical test. The main objections of the Board were, 1st, doubt as to clearness of image and, 2nd, the claim that there were few harbors where such instruments could be placed at suitable heights above the water.

The precise form of the instrument cannot be given. In any case the lens must be achromatic, with a focal length of not less than three feet and of sufficient diameter to insure, on a plane surface, an inverted, brilliant, rectilinear and clear-cut image, of objects from 500 yards to 10,000 yards distant, inclosed within a horizontal angle of at least 40°. The plane of the image must be perpendicular to the axis of the lens, and the optical center of the lens must be in the axis of rotation of the instrument. There must be no distortion or enlargement in the center of the image, such as occurs with the ordinary lens; straight lines must be shown as straight lines. The image must be sharp and distinct to the very edge of the plate and perfectly flat. It is proposed to mount such a lens, which will, of course, consist of a combination of lenses, in an ordinary camera obscura with its line of collimation horizontal. Back of the lens fix a mirror at an angle of 45° with the horizontal plane and above this in a horizontal position fasten a plate of ground glass. The mirror, the glass and the telescope should all be firmly attached to the same frame having a motion of rotation about a vertical axis through the optical center of the lense. The glass and mirror should be provided with adjusting screws and levels for adjustment and verification of the accuracy of their positions. The mirror should have a rack and pinion for making such slight alterations in the focus as may be necessary. The glass should be at the focus of the lens so that, as reflected from the mirror and looked at from above, the image would appear erect and well defined. Around the rear of the mirror box should be an azimuth circle with an index and dial reading to minutes. As this circle must be at least three feet in diameter, the graduations could be easily read. A geared wheel in rear, working in a rack on the circle, should move the instrument in azimuth.

On the ground glass draw a series of curves representing the loci of all points at the same distance from the foot of the vertical through the optical center of the instrument; also radial right lines showing the azimuths of all positions, and along the particular line showing where the vertical plane through the line of collimation cuts the horizontal plane of the water level, indicate as small graduations of range as may be easily read. The glass must be accurately oriented so that the field shall be symetrically disposed with reference to this graduated line. The ground glass gives a more distinct image and better illumination than can be obtained by reflecting onto a table. A hand magnifying glass can be used to enlarge the image and scale or to secure a more distinct view in cloudy or foggy weather. A rough sketch of the instrument is shown, in which L is a lens, M a mirror, G a finely ground glass and P a rack and pinion for making small alterations in the focus.



The camera would be used as depression instrument, its base being the height of the lens above mean low water, consequently it cannot be used to the best advantage on low sites, but this objection it possesses in common with all vertical base instruments and cannot be, therefore, specially urged against it. Located at a suitable height of 60 feet or over, it can be mounted on a front pintle carriage and exposed through an embrasure to obtain limited views, and on rollers on a circular track for all round views.

Owing to the wide field of the objective, 40°, the whole harbor is spread out to the observer, who has no difficulty in finding his target, thus eliminating error. Forty degrees will cover the entire navigable channel leading from the Capes to Fort Monroe. The observer simply looks at the picture on the plate, notes when a vessel's water-line crosses a line on the glass and reads the range at once without taking his eyes off the target. No cranks to turn, no bearings to wear, no distracting manipulation, nothing to do but note the range curve and azimuth line when the time to observe arrives. If accurate azimuths are also desired, he traverses the instrument so as to keep the graduated radial line of the ground glass so that it passes through the target. At the signal to read, he notes the range along this same line and reads the azimuth from the circle and a minute dial in the rear.

The chief merits are: 1st, it enables the observer to cover a wide field of view, and to determine simultaneously ranges and azimuths to any portion thereof; it does not narrow observation to the water-line of any one particular vessel, but takes in the whole scene of the action; 2nd, the determination of a position is done by inspection at a glance, no manipulation being necessary. Errors would be, therefore, much smaller and mistakes ought to be eliminated; 3rd, the time required for observation is practically nothing. 4th, There can be no parallax. 5th, There are no gears to wear.

In working out the details of the system, a number of points deserve mention and some very serious objections present themselves. The art of lens making has so far advanced in recent years that it is possible to obtain delicate definition, flatness over the entire plate, absence of distortion, correct rectilinear outlines and good illumination with a field up to 60° or 70°. Such a lens with a focal length of 44 inches, 5½ inches in diameter, working at an aperture of F8, will cover a plate 50 inches in diameter and all points beyond 2000 feet will be in universal focus, so that for all practical ranges no adjustment will be needed. There would be no difficulty in securing a lens to fulfill any required conditions, provided the necessary price be paid, about $500.00.

The mirror should be about 30" x 60" and mathematically true. Its manufacture and mounting while requiring careful work and being rather expensive, presents no difficulties which cannot be overcome.

The ground glass plate can be easily made. The calculation of the curves is a simple problem in conic sections; once calculated, they can be drawn with mathematical accuracy. All space above a horizontal line through the center of the illuminated circle would be useless and could be cut out by making the mirror only half as wide as it is long. Below that line would appear all the space between the instrument and an infinite distance; the portion for subdivision would be included between a range of 500 yards and 10,000 yards and would cover about 25 inches, the divisions for the nearer zones being much the larger. In the Lewis Range Finder, the actual motion of the eye-piece is from 1″ to 3″ for the same limits of range, which by a system of gears is multiplied until it is read around the circumference of a circle 12½ inches in diameter, giving about 38″ for subdivision. In the camera, it is impossible to multiply the scale mechanically and a mathematical investigation would show that a degree of accuracy greater than that of the Lewis Range Finder cannot be obtained on a plate of that size. At the longer ranges beyond 6000 yards, this inability to read closely gives rise to errors in range which are inadmissable in an instrument designed to shoot by, being greater than the mean error of the gun. Cutting down the field to 20°, the portion included between the ranges of 500 yards and 10,000 yards could be lengthened to 36 inches by giving the telescope a constant inclination to the horizontal of about 8°, with corresponding changes in the lens, positions of the mirror and glass, and the curves on the glass. The advantage of a very wide field of view would be lost, while a degree of accuracy as great as that of the Lewis Range Finder could be obtained.

When the line of collimation is horizontal, the curves of equal ranges are those produced by cutting a series of right cones with circular bases and a common vertical axis, by a plane parallel to the axis. The curves will, therefor, be hyperbolas, having an equation of the form

$$(x^2 + a^2) \tan^2 v = (z - h)^2$$

in which x and z are the horizontal and vertical coordinates of points of the curve; h is the vertical height of the instrument above mean low water; $\tan v$ is the fraction having the instrumental height as a numerator and the range as a denominator; and a is a constant depending on the coefficient of refraction of the lens, the range and the focal length. Its value can be found for any particular lens and will be constant for all points on the same curve.

In case the instrument be inclined down at an angle with the vertical axis, about which it revolves, the curves also become hyperbolas with a similar formula but a little more complex.

The radial right lines drawn on the glass can be sufficiently numerous without obscuring the image, to indicate the azimuth within narrow limits, subdividing lines being introduced beyond a range of say 4000 to 5000 yards. The observer is thus enabled without any manipulation, to read both the range and azimuth of any position in the field directly from the image.

To correct for tide and refraction, no simple accurate method has yet been evolved. It may be done accurately by raising and lowering the whole instrument with the tide, but this involves a complication of mounting and a degree of exposure which, for variations of tide greater than two feet, are inadmissable. It may be corrected approximately by making the glass adjustable, so that a suitable movement horizontally to the front or rear, as indicated by a scale showing the amount of shift necessary for each foot of tide, would make the reading accurate for a range of say 6000 yards and approximately accurate for all other ranges. Two scales could be had, one correcting at 7000 yards and the other at 3000 yards, thus covering all important ranges. Depressing the lens below the horizontal, as is done in the Lewis Range Finder, will accomplish the same result, and would probably be easier. In actual practice, the points where images of prominent land marks fall when the instrument is in position for work can be marked, so that it would only be necessary to turn the instrument on these datum points and make it read the proper range in order to correct for tide, refraction etc.

As mathematically true mirrors of large size are expensive, it has been proposed to fix the ground glass in a vertical position at the focus of the lens as in an ordinary camera and then use Hastings-Brashear erecting prisms to give an erect image. This simplifies the mounting, would be less expensive, makes the original adjustments fewer; gives one less part to be broken and would probably give as large a percentage of light as when reflected from a mirror. It would be easier to examine the glass in a vertical position.

CONCLUSIONS.

The results of the investigation seem to show that as compared with the Lewis Range Finder, the camera is at a disadvantage as regards its ability to read ranges accurately, owing to the fact that the absolute length of the scale is too small to admit of sufficient subdivision. Its great advantages are a wide field of view, ease of reading range and azimuths, perfect simplicity of operation, the entire absence of gearing, ratchets, pinions etc., requiring delicate adjustment and susceptible to wear; and the total elimination of parallax. There may be any number of observers and when once adjusted, it remains in adjustment. The correction for tide and refraction while approximate, is as nearly accurate as in any vertical base instrument yet devised. Its lack of close reading unfits it for use in the Battery Commander's station as the information required there is the accurate range and azimuth of a definite target, designated by the fire commander. A high degree of accuracy is essential, while a wide field of view is of no special advantage.

The requirements of the Fire Commander's station, however, are very different. He must "observe fully the whole of the water area and the approaches thereto"; he must see all the targets at once and know their approximate range to enable him to "assign targets to his batteries," to "observe the course of the engagement"; to "change the target when necessary"; to "change the projectile" and to "concentrate or distribute the fire". He does not need to know the exact range or azimuth of any one vessel, consequently a Lewis Depression Range Finder is ill adapted to his needs. He has no time to go searching around over the whole field of fire trying to determine by a separate operation the range of each of a number of vessels. The camera obscura will give him at a glance the range within 100 yards and the azimuth within a degree, which is as close as would ever be required. The whole harbor is spread out before him like a picture, giving at any instant all the information he desires. He can select the targets for the various batteries from a consideration of the whole situation. As the vessels approach critical ranges, either singly or all together, that fact is evident and the projectiles can be changed accordingly. Hence, we may conclude that, while the camera obscura offers no special advantages over the Lewis Range Finder for use in the Battery Commander's station, it is by far the most suitable instrument for use in the fire commander's station.

(A special study, assigned in the Department of Artillery, U. S. Artillery School, Class of 1901.)

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COMMENTARIES ON CONTEMPORANEOUS ART OF DEFENSE.

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(Reprinted from *Revue de l'Armée Belge.*)

Lieutenant Colonel Rocchi of the Italian Engineers has published in the *Corrispondenza*[*] a Summary on the present state of the Art of Permanent Fortifications. We desire to take advantage of the appearance of this study, in order to present to our readers the principal ideas enunciated by this eminent Italian Engineer, a description of the most recent transformations in the art of permanent fortification and the desiderate to be fulfilled by the latter, according to the late works of General Brialmont that illustrious veteran of this Art, who, during the last forty years, personifies, we may say, the Art of Defense.

With Lieutenant Colonel Rocchi,[†] we can divide the history of the art of defense into four periods:

1. The period of bow-spring ballista, etc., or the period of military machines, which lasted thousands of years.
2. The period of smooth-bore artillery which comprises some hundreds of years.
3. The period of rifled cannon which extends over some dozens of years only.
4. Finally, the period of armor and beton, or concrete, which commenced with the introduction ot the torpedo-shell.

The most characteristic times of this history are those which mark the passage from one period to the following one. The plans for the defense of Antwerp, for example, made in 1858, were adopted in 1859 and were carried into execution in 1860. They decisively established the superiority of the polygonal system of fortification over the bastioned trace.

But the appearance in 1860 of rifled siege artillery led Major Brialmont to modify the original trace and to put into application the principles set forth in 1863 in his work: "Studies on the defense of States and on the Art of Fortification."

The Antwerp type belongs, then, to the epoch of transition which marks the change from smooth bore to rifled artillery. This change caused the art of defense to enter upon a new phase and established the principles of organization of places with detached forts, or modern fortified positions.

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[*] March-April number, 1900, of the *Corrispondenza-Giornale di Scienze Militare.*

[†] This classification has been made by General César Cui in his "Summary of the History of Fortification," 1897, and has been adopted by Prince Toumanoff in his work "Preparation of Fortresses with a View to Repulsing a Sudden Attack."—*Revue de l'armée Belge*, 19th year, Vol. III, 1894.

The use of modern cannon and new explosives brought about a revolution in the art of fortification of no less moment than that which marked the invention of gunpowder at the close of the 15th century. The ideas of our great military engineer developed very soon in some new writings and studies.[*] In these works he upheld the Antwerp type of defense as regards essential lines, and advocated the limited use of armored constructions and cupolas. In 1885,[†] General Brialmont recognized the necessity for a more extended use of this kind construction, cupolas included ; as a result, he devised the *armored forts* which fulfills all the conditions imposed by modern artillery.

In 1888, after the tests at Malmaison, it was announced that the day of permanent fortifications had passed and that it was no longer possible to construct forts in such a manner as to resist the effect of the torpedo-shells. Not accepting this opinion, General Brialmont proposed successively some new types of armored forts.[‡] These were adopted at Bucharest, at Liege and at Namur, and subsequently at Antwerp.

It was according to the plans laid down in *The Art of Fortification of the Present Day*, and with due consideration of the principles enunciated in *the influence of plunging fire*, etc., that the intrenched camp of Bucharest was constructed commencing in 1883. This work comprises 18 forts and 18 small forts (*fortins*) or intermediate permanent batteries.

The 21 forts of the Meuse were built from 1888 to 1891. These works belong, accordingly, to the time of armored fortifications.

Masonry work from this time forward had to be made of beton, of Portland cement and siliceous pebbles, the thickness of arches varying, according to their span, from 2 to 3 meters. The tests made at Brasschaet[§] tended to confirm these provisions. The most recent tests, undertaken to some extent in every country, and particularly those lately made in Germany, have demonstrated that arches made of cement beton, constructed like those of the forts on the Meuse, are capable of resisting every kind of artillery fire.

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[*] The Defense of States and Intrenched Camps, Paris, 1867. Treatise on the Polygonal System of Fortification Brussels, 1860. Fortifications with Dry Ditches. Brussels, 1872 Study on the Fortification of Capitals and the Investment of Intrenched Camps, Brussels, 1873.

[†] The Art of Fortification of the Present Day, Brussels, 1885.

[‡] The Influence of Plunging Fire and Torpedo-shells on the Art of Fortification. Brussells, 1888. Fortified Regions. Their Application to the Defense of Several European States, Brussels, 1890. The Defense of States and the Art of Fortification at the End of the 19th Century, Brussels, 1895. Coast Defense and Permanent Bridge Heads, Brussels, 1896. Progress of the Art of Fortification Since the Time of Vauban, Brussells, 1898.

[§] Proving-grounds, 10 miles N. E. of Antwerp.

The question of cupolas remained in suspense until after the trials at Cotroceni (1885-86). The improvements made in armored turrets by Major Mougin and by Schumann-Grüson made it possible, from that time on, to consider as solved the problem of the protection of guns and cannoneers against the powerful destructive effects of modern artillery. Since that time, success has been achieved in remedying all the defects and inconveniences that yet existed in such constructions.

The most serious of these inconveniences was smoke, which rendered duty in cupolas very distressing and painful. General Brialmont has remedied this by closing up the embrasures by elastic rings. These ring-obturators were for the first time made use of in the Belgian cupolas in the forts on the Meuse. It constituted an advance that won over to the use of cupolas the majority of those opposed to them.

We may class in the *School of armored forts* the projects developed by Captain Deguise in his excellent work, "The Art of permanent fortification applied to the Organization of fortresses," published in 1896.

Although the professor of fortification in our school of application departs on several points from the ideas of General Brialmont, notably as regards the rôle and importance of the intermediate batteries and of the accessory defenses, also in the use and distribution among the various works of guns of different calibres, the general principle of organization which he enunciates consists in saying that,—*the points of support should be capable of engaging at great distances, should be able to offer strong individual resistance and assure the flanking defense of the intervals and likewise the defense of the ground in front of the collateral forts.* This conforms to the underlying ideas of the Master.

On the opposing side, without renouncing the use of armor, it is desired to suppress the works of independent defense and to organize *armored fronts* made up of a number of small fixed or mobile works of mutual defense. The chief of this school is General von Sauer, of the Bavarian artillery, whose ideas were spread abroad by Major Scheibert*, Captain Boninitzki of the

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* This Engineer has advocated the creation of a *mobile fortification material*, guns, cupolas, blindage materials (armor plating), and railway material, etc., which would be kept in certain localities so that *provisional fortresses* could be raised at points the strategic importance of which would be recognized the moment war broke out or during subsequent operations.

Russian Engineers, and worked up into plans by Colonel Schumann and the Swiss Captain Meyer.

Present ideas in the matter of fortification commenced to take a wrong direction, says General Brialmont, after a distinguished artillery man, General von Sauer, in 1880, advocated a method of attack which tended to discredit our fortresses completely. He claimed, in fact, it was possible to take possession of some of the best of them by open assault after a bombardment of short duration.

It was especially against the belts, composed of large forts, of these intrenched camps, that he directed his attacks; at first alone, then afterwards with Major Schumann of the Engineers whom he had converted to his ideas. Both proposed to substitute for these girdles of forts many lines of redoubts or permanent batteries.

We may consider also as members of this school, those anonymous authors who, immediately after the trials at Malmaison, urged in many treatises, the dispersion in length of the elements of the defense, the reduction of relief to a minimum, the suppression of that obstacle of tradition, the ditch, and the substitution therefore of a network of accessory defenses.*

In fact, the two opposing schools represent in the domain of defensive art the principles of the deep formation (armored forts, Brialmont) and those of the shallow formation (armored fronts); or order in column and order in line in the domain of tactics.

It is clear, says Lieutenant-Colonel Rocchi, that the solution of the problem of the defense rests not in the exclusive application of the one or the other principle, but in their judicious coordination.

It is necessary to notice particularly that the advocates of armored fronts are very exclusive and often base their opinions on the question of principle, or on purely theoretical conceptions, while the Brialmont school is above all with the times, takes into consideration strategic situations of the *terrain*, and does not bind itself to formulae.

As a rule, the experience of modern war has demonstrated *in tactics* the superiority of order in colum, but as its formations became too dense in the presence of the ballistic powers of new small arms, a mean has been generally adopted : line of columns, that is to say a judicious combination of the shallow formation, or extended order, to diminish losses in the firing line, and of the deep formation to profit by the offensive power of shock action.

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* **Mistakes in the Present System of Fortification, Paris, 1887. The New Art of Fortification, Rheims, 1888. Forts and Melinite, Paris, 1888.**

It is in this general expression that the leading idea of the school of *the armored fort* precisely lies, and General Brialmont, its Chief, has formulated its propositions, basing them on concise demonstrations, supported each time by developed examples and actual applications.

Besides, Lieutenant Colonel Rocchi sets forth the very weakness of armored lines, where the least effort at one point can cause the fall of the whole system. The principle of mutual defense, says General Brialmont, has rather a theoretical value. When the defense of the points of support is assured only by some disappearing cupolas, their resistance will indeed be slight. As a fact, when several works are attacked simultaneously, especially at night, each one of them will occupy itself only with its own defense. If each work is not protected by a well flanked ditch, it is safe to say that it is not secure from an attack by open assault or by surprise.

The arrangement of the defensive points on several lines in quincunx order* would be excellent if the small forts (*fortins*) were impregnable to an attack by assault and were provided with armored armament. These conditions would cause them to be classed in the catagory of *armored forts*. It must be observed, also, that the multiplicity of works leads to a multiplicity of commands, an evident cause of weakness.

These considerations should cause intrenched camps organized in this manner to be disapproved.

Great fortresses constituted with firm points of support will facilitate armies so much the more in the accomplishment of their tasks as the intrinsic resistance of these supporting points may be relied upon.

Nevertheless, in the beginning, the leading spirits in favor of armored lines aroused great enthusiasm and achived ready success. The fortifications of the lines of the Sereth were constructed under the influence of their ideas.

But after a few years, this infatuation diminished a great deal, especially in Germany,† where the number of partisans in favor of the linear system of fortification is every day growing less. The works recently constructed in that country all belong to types of Brialmont forts, reduced in scale somewhat, as regards dimensions and armament, and simplified in their interior organization, on account of financial reasons.

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* General von Sauer has proposed to make up intrenched camps of two lines of works spaced from 1000 to 2000 meters apart. These works to be turrets provided with a cupola, requiring for their security and for the service of their two guns only twenty men. (Progress of the defense of States.)

† Captain von Schroeter of the Engineers, professor at the War College at Berlin, declared at a conference held in 1885 at the *Société Militaire* that the Schuman prapositions do not stand serious examination and that a second application of the system as carried out in the lines of the Sereth will not be made.

The criticism directed against the Brialmont armored forts in respect to their enormous development and their excessive cost, arising from the exclusive use of cupolas and the grouping of these in their protecting masses of beton, gave birth to various schools that may be considered substantially as mere derivatives from the fundamental principles of the mother school. Completely preserving the general conception of co-ordination of the principles of concentration and development of the elements of resistance, as laid down by the Chief, these authors propose to remedy the defects above mentioned by various dispositions of a technical and especially of an economical order.

One of these subschools desires that the forts should constitute the defense like bastions in the bastioned system, that they should possess the power of distant frontal action, and assure the flanking defense of the intervals (curtains). It admits the moderate use of armored constructions and cupolas, which should be able to engage in both near and distant action. It advocates, moreover, the reduction of the extent of the forts to a minimum and the simplification of their interior and exterior organization, in the hope of keeping the cost of such works within relatively modest limits, *compatible with the exigencies of an independent defense.* This is the school of *reduced armored forts.*

In this catagory may be classed the projects of Colonel Crainiciano of the Roumanian Engineers, General von Brunner, Colonel von Leithner and other Engineer officers of the Austro-Hungarian army; the plans of Captain von Rehm of the Austrian artillery, Captain von Schroeter of the Prussian Engineers, Colonel de la Llave of the Spanish Engineers, and likewise the studies of Colonel Rocchi,* which have been published principally in the *Revista d'artiglieria e genio* during various years.

An examination of the difference which separate the school of *reduced armored forts* from the Brialmont school properly speaking, shows that they exist mainly in words. In stating that the reduction in extent and the simplification of the organization of of the works themselves should be compatible with the exigencies of an indepeudent defense, these authors who desire to depart from the path indicated by the chief of the *armored forts* school, prove that they remain in perfect accord with him on broad general lines; details are in each particular locality a matter of application of these principles to special circumstances. General Brialmont's types of armored works are far from being unchangeable. Certain authors have sometimes even reproached him for the contrary.

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* E. Rocchi —The Form of and the Materials Used in Modern Fortifications, 1888, vol. I and II. The Fundamental Principals of the Art of Fortifications, 1889, vol. I and II. The Present State of the Art of Fortification.- General Considerations: Principal Elements of an Ordinary Defense, 1891, vol. II. Notes on the Principles of the Art of Defense, 1897, vol. II. On the Application of the Principles of the Art of Defense, 1898, vol. I.

Another sub-school desires "*the separation of the distant defense and the near defense.*" It proposes the construction of a line of resistance formed of defensive points, or points of support, the action of which is to be limited to the near defense and the flanking defense of the intervals, reserving distant frontal action exclusively for elevated batteries in these intervals. These batteries are designed and destined to engage and sustain the artillery attack.

The originators of these ideas, in so far as what is fundamental, are General Schott of the Prussian Army, Colonel Voorduin of the Dutch Engineers and Colonel Laurent of the French Engineers. In this catagory may also be classed principally the late works published by Colonel Lo Forte, Italian Engineers, Major Borgatti, Captains Sandier and Vallermand, French Engineers, the Russians Miaskowski and Boninizki, the Englishmen, Lewis and Clark, and Cool of Holland.

The recognized chief of this school is General Welitschko of the Russian Engineers, who, in his projects, lays especial stress on the mobility of the artillery, by making use, on a large scale, of communications by means of railways. But the characteristic and revolutionary note in his system is the tendency towards the desire to exclude radically the use of all armor.

To that effect, this Russian engineer draws attention to the fact that the sum necessary to construct 8 or 10 cupolas is sufficient for laying 8 or 10 kilometers of railway track and for acquiring the artillery and other active elements of the defense, which, according to this author, will render services incomparably more important. The points of support should contain only light pieces and a small garrison; the intervals should be about 2,500 meters (effective range of shrapnel fire); the permanent batteries of security should be armed with cannon or mortars for which General Welitschko prefers some kind of disappearing mounting to any form of cupolas. The heavy guns and mortars intended to resist the artillery attack should be installed in the intervals. Besides this, as Lieutenant Colonel Rocchi himself proposes, numerous artillery positions should be provided and connected one to another by communications hidden from view, in such a manner as to facilitate rapid changes of position. In order to justify his preferences, the professor of the St. Petersburg Academy points out the enormous cost of cupolas, their imperfections and the uselessness of having the points of support capable of an absolute resistance.

The advantages of mobility of armament are certainly greater for the defense than for the attack ; all other things being equal, with this organization, the attack will never attain the degree of power of the defense. The ground about fortified places can, in fact, be strewn in time of peace, with belt railways and radial tracks along which materiel and even armored trains can circulate.

We will remark, however, that mobility is not the exclusive property of the school of separation of the defenses in general, or of the Welitschko school in particular. It pertains also to the school of "forts of independent defense."* Moreover it is necessary to note that the extended use of railroads is not applicable to all terrains, a circumstance that will frequently diminish the value of this means of action.

We have already partially given a refutation of the so-called imperfections of cupolas. The objection that the besiegers' batteries of mortars and howitzers could hit three of four cupolas at once is well founded, but this criticism applies with greater force to forts without cupolas, in which a great number of guns are placed in a straight line along fronts and are subjected to the effects of enfilade fire. It is true that if the cupolas were spaced at greater distances the chance of hitting them would be diminished; but to attain this end, the forts would have to be given an extention at times inadmissible. Between two evils, we must choose the lesser.

However that may be, armor and beton masonry offer considerable resistance, especially when the cupolas constructed in a central mass of the same, are screened from the enemy's view. By such an arrangement however, it is not at all meant that the advantages of direct fire for cupolas should be given up.

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* In his recent study on siege tactics, (Collection of Technical Works of the Engineer Officers of the Belgian Army, II, 1900.) Major Deguise advances the opinion that the materiel for narrow guage railways and the rolling stock should be considered as *materiel of position and siege materiel.* He declares, moreover, that *great mobility* of the artillery intended for engaging and sustaining the artillery duel is an absolute necessity in the present day.

The concentration of the principal elements of the defense at a few points should not cause it to be forgotten that though this fixed artillery may not posses superiority in numbers, it does in calibre and security; its efforts will be sustained and complemented by the mobile armament of the intrenched camp, which, *a priori*, may be considered as at least equivalent to the gun-trains which the enemy can bring up.

As to the excessive cost of armored forts, Lieutenant Colonel Reinhold Wagner* of the German Engineers has conclusively shown how much greater are the expenses connected with forts without overhead cover, from the triple point of view of coast of the works themselves, armament and personnel. In comparing the cost of the 21 forts of the Meuse to that of 21 ordinary forts with armament with overhead cover, constructed on the same sites, Colonel Wagner has calculated that the cost of 21 ordinary open forts would amount to 93,885,000 francs. Now the 21 forts on the Meuse cost only 70,600,000 francs; the saving realized, accordingly, has been 23 millions. An armament without overhead cover would have necessitated 562 guns as compared to 212, the present number, (135 of large caliber and 77 rapid-fire guns, caliber 57 mm.).

As a general rule, those desirous of taking the large caliber artillery out of the forts, claiming that the latter should not directly cover the ground of the attack nor take part in the artillery duel, lose sight of the fact that the principal guarantee of the preservation of these batteries established in the intervals, lies precisely in the protection that they receive from the artillery in the forts, these latter guns being practically indestructible due to their fixed installation in cupolas or in armored batteries.

The engineers in favor of separation of the near and distant defense do not admit that lateral fire or flanking defense of the intervals, which should be assured up to the very last moment, can be entrusted to guns charged with sustaining the artillery duel from the beginning of the investment until the attack at close quarters; they deny the relative invulnerability of cannon installed in cupolas and, consequently the possibility of preserving, during the whole duration of the siege, pieces that will be subjected to constant fire from the enemy's batteries.

In order to satisfy such conditions, it becomes indispensable, according to their views, to devise special works that will be indestructible, hence hidden and secure from the distant fire of the attack (*batterie de pieces traitresses*, (traditori), i. e., protected batteries under the flank of or hidden by the forts).* The necessity for the defense to be able to rely upon some guns of long range at any moment whatever and principally during the first phases of the siege is irreconcilable with placing these guns in simple batteries open at the gorge, incapable of a proper resistance and subject to inevitable surprises.†

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* Jahrbücher für die deutsche Armee und Marine, 1892.

It would seem that therein lies the principal point of weakness of the proposed defensive organization of this school which separates the two defenses. By stripping the forts of their long range artillery, it becomes impossible for them to destroy or menace the artillery of the attack, while the great aim of the latter will always be to deprive the batteries in the intervals of the extrinsic protection of these forts.

The withdrawal of heavy artillery from the forts was properly urged during the epoch of transition which marked the change from rifled artillery to torpedo-shells, when masonry and traverses proved insufficient to protect their armament from those modern projectiles. The majority of these pieces were then installed in wing batteries, and in the forts were left only those guns intended for repulsing attack by assault. There is no longer any reason for such a disposition, since cupolas and modern masonry work are able to resist once again the latest means of destruction.

General von Sauer, himself, has already recognized, in 1882,‡ that conditions are no longer the same as formerly and that the defense has regained much ground.

Again , the establishment of the intermediate batteries is not entered upon until the moment it is known what sector will be attacked; and even though they may have been constructed in advance, would it not be imprudent to place the most powerful guns in batteries which may easily fall into the besiegers' hands by an attack by open assault.

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* According to Major Deguise these permanent and indestructible works form an integral part of the forts and are established either in a salient on the gorge front, or towards the extremities of this front, or, again, in the capital of the fort; sometimes, however, the "traditor" batteries will be placed outside of the points of support. In vol. II, 1900 of the "Collection of Technical Works, etc.", already cited, the author reverts again to the reasons which have caused him to prefer "traditor" batteries. As a new argument, he lays stress on the fact that the assailant will be obliged to erect and arm "counter-traditor" batteries at some hundreds of meters only from the principal line of the fortress, in order to sustain and support his *march of approach* and to annul the flank action of the "traditor" batteries.

According to Colonel Voorduin's plans, the "traditor" batteries are masked casemate batteries in the gorge. They are entirely masked by the fort itself from the view of the enemy in the angle of front fire.

† Colonel Welitschko proposes the construction of one permanent gun-battery and two howitzer-batteries in each interval; Colonel von Leithner, two gun-batteries.

Major Deguise advocates a mixed system; he would establish *forts of the first order*, comprising in their armament some guns capable of engaging at long range, and *forts of the second order*, containing only pieces intended for the attack at close quarters. He is of the opinion that the artillery combat will be sustained principally by the batteries established in the intervals and completely prepared, during time of peace, in sectors of possible attack. We will speak of his "traditor" batteries later on.

‡ Beitrage zur Taktik.

Temporary works do not offer, moreover, any protection against plunging fire, for shelters of wood and of rails, as of old give no defense at all from the effects of howitzer and mortar fire. The use of transportable cupolas and mobile armored mountings partially overcomes this difficulty but their employment is hardly practicable except for guns of rather small caliber. When it is desired to make use of powerful cupolas, from one thing to another, the point is soon reached of making them permanent, or at least of constructed, during time of peace, the supporting mass of beton which is to serve as the foundation and for the protection of the cupola. In other words, the propositions of the engineers of the school of armored forts are finally admitted. The true place then for the large caliber artillery is in the forts and not in batteries constructed at the last moment when and where needed.

[Translated by Captain A. Hero, Artillery Corps.]

(To be Concluded.)

A DISCUSSION OF THE ERRORS OF CYLINDRO-OGIVAL PROJECTILES.

Translated from the French of General Donny in *Revue de l'Armée Belge* of January-February, 1900,

By J. M. WILLIAMS, 1st Lieut., Artillery Corps.

(Concluded).

APPLICATION OF THE PRECEEDING THEORIES.

In order to construct, conformably to the preceding theories, the table of errors of a new piece of ordnance, we shall use the result of firing done for the determination of the elevations, as well as the results of all other experimental practice.

Let us consider first the vertical errors.

The table of elevations permits us to choose, from among the different laws of the resistance of the air, that law which best applies to the trajectory of the new piece. The equation of this trajectory will then be determined, and will enable us to calculate afterwards, as we have done in this discussion, the expressions representing the partial errors due to the still unknown variations $\Delta\varphi$, Δv, and Δk.

The total error, Δy, will be represented by the relation:

$$\overline{\Delta y}^2 = A\,\overline{\Delta\varphi}^2 + B\,\overline{\Delta v}^2 + C\,\overline{\Delta k}^2,$$

in which A, B, and C are known functions of the angle of elevation of the range, and of the coefficient of the resistance of the air.

For each of the ranges we shall substitute in this equation: for Δy the observed mean vertical error; and for A, B, and C their calculated numerical values. Thus we shall obtain a series of equations in which $\Delta\varphi$, Δv, and Δk will be the unknown quantities.

We shall solve the equations by the method of least squares, which is here very simply applied, since these equations take the simplest form:

$$ax + by + cz = d,$$

when we place $\overline{\Delta\varphi}^2 = x$, $\overline{\Delta v}^2 = y$, $\overline{\Delta k}^2 = z$.

The results obtained will enable us to trace lines representing the partial errors, and a very simple graphical construction will then give the curve of total errors for all the ranges.

If the experiments had furnished enough observations of initial velocity to determine directly ΔV, we might consider that quantity as known and then the equations above would have only two unknown quantities, $\Delta\varphi$ and Δk; or indeed we might take for ΔV the mean value gotten for it with the aid of the errors at the target and by means of the chronograph, then introduce this mean value into the original equations and calculate anew $\Delta\varphi$ and Δk; in this last method all the results of experience would be used.

The errors in range would be calculated either by means of the vertical errors and the angle of fall, or directly as we have done above, using the equation that gives the error in range.

Finally the lateral errors are represented, as we have seen, by

$$\overline{\Delta z}^2 = (x \tan \overline{\varphi})^2 + Q t^2.$$

Experience giving for various ranges the value of Δz, and it being possible to calculate the time for each of those ranges, the relations above will furnish a large number of equations in which $\tan \varphi$ and Q will be the unknown quantities; the method of least squares will then enable us to assign values to these constants. Here again the equations may be put under the simplest form

$$Ax + by = c$$

We afterwards proceed with the tracing of the component curves of error, then with the tracing of their resultant.

These processes are evidently much superior to the graphical constructions ordinarily employed, particularly if we possess for different ranges the results of only a small number of shots. In this last case the points through which it is necessary to trace by guesswork the curve of errors, are so irregularly placed that the tracing of the curve is absolutely uncertain: in all cases it is very difficult to take into account the weight of each point.

Let us add that, in the graphical construction of which we are speaking, it is impossible to make use of the data furnished by the chronograph, and these data afford a valuable balance in favor of the method we have praised.

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This method seems to be capable of other applications.

If it be a question of experiments with a new piece of ordnance, knowledge of the values of the factors $\Delta\varphi$, Δv, and Δk may give valuable information.

Let us suppose that the firing of this piece is not satisfactory: if we compare the partial errors with those which occur in a system that is recognized as of good standing, we shall discover to which one of the groups of causes of error is to be attributed the lack of accuracy. Undoubtedly this will not immediately point out the changes that it would be well to make in the features of the piece, the charge, and the projectile: we shall not know the remedy, but we shall have a diagnosis that will guide us in our search for a remedy.

If, for example, it is the value of $\Delta\varphi$ that is too large, we must examine the carriage, the centering of the projectile, and the twist of the rifling. If Δv is excessive, the defect in the fire is attributable to the powder, to the too much reduced length of bore, or to an irregularity in the position of the projectile in the chamber. Finally if Δk is abnormal, the position of the center of gravity of the projectile, the length of the projectile, or the twist of the rifling is to be thought the cause.

It is true that two of these matters of information may be dedetermined by other means: thus practice at short range would give the value of $\Delta\varphi$ and the chronograph would aid in determining Δv; but in order to obtain these values with some accuracy it would require special practice with a large number of shots. Our method allows, on the other hand, the use of all the results of practice without exception, and thus enables us to save both time and money—a matter that may be of the greatest importance.

⁂

Again, we may apply this theory to investigations looking toward the increase in accuracy of fire of *matériel* already in use.

Let us assume that the 8^c gun is in question, and that it is foreseen that this piece is destined for use principally at ranges between 1000 and 1600 metres. It is enough to glance at the lines that represent the partial errors, in order to become convinced that it is the variation in angle of departure that must be reduced. If, for example, by the use of a better constructed carriage we succeeded in diminishing this variation by half, the total error in range at 1400 metres would fall from $11^m.80$ to 9^m; while a diminution by half in the variation of the initial velocity would leave the total error at 11^m, that is to say at very nearly its original value.

If it were a question, on the other hand, of employing the same piece at 3000 metres, it would be very useless to attempt to reduce, even by half, the variation in angle of departure; for the total error in range would thereby only be brought from $21^m.35$ to $20^m.70$, an insignificant reduction: the means of improvement must therefore be sought elsewhere.

This investigation shows that the best mounts should be reserved for firing at moderate and at short ranges.

By applying the same reasoning to small arm fire, it stares us in the face that it is the living carriage, the rifleman, that is the vastly predominant cause of error--unless in the case of very exceptional marksmen. Thus it is mathematically demonstrated that it is much better to appropriate money for increasing the number of cartridges to be used in target practice, than to appropriate the same money for bestowing upon the infantry a new rifle that would excel only through its accuracy when fired from a rest.

⁂

Knówledge of the partial errors will, finally, be of use when changes are made in one of the elements of a system of ordnance.

If, for example, the use of a different mount is decided upon, the mean error, under this influenee, will be changed for all ranges; and in order to determine its altered value by the present method, it will be necessary to have results of firing done at different ranges. By the new method practice at one range will suffice; for, since the use of a new mount can have changed only the variation in the angle of departure, but one equation is needed in order to determine it.

On the other hand, were it a question of a change of powder, and were the initial velocity to remain almost the same, only the variation in velocity could be modified; and it would be sufficient to use the chronograph in order to determine its new mean value, and consequently the new total error.

NOTE ON THE LE BOULENGE CHRONOGRAPH'S MEAN ACCIDENTAL ERROR.

Each velocity indicated by the chronograph is affected with a constant error and with an accidental error.

In a series of observations in which the plant, the apparatus, and the observer remain the same, the size of the errors can vary with only the velocity of the projectile; now, in the case of one and the same gun firing the same kind of projectile, with the same charge, the variations in velocity do not reach an average of 1% of the velocity; the errors made by the chronograph vary then in like proportion: that is to say they may be considered as independent of the small differences that exist between the actual velocities of the projectiles.

Appendix III gives some series of double observations relative to the 12^c shell, and gotten under these conditions: the velocity of one shell was taken at 35 and 36 metres by two chronographs, each having its circuit pass through two targets separated by 50 metres.

From 35 to 36 metres the retardation of the 12^{e} shell is about $0^{m}.07$, a value that may, for the same reasons as above, be considered constant for all the projectiles used.

Let

n = the number of shots of one series;

$\nu, \nu', \nu'', \ldots$ = the true velocities of the shells at 35 metres;

$\alpha, \beta, \beta', \beta''$ = the constant error and the accidental errors of the first instrument, each taken with its proper sign.

$\gamma, \delta, \delta', \delta''$ = the corresponding errors of the second instrument, also taken with their proper signs.

τ = the shell's retardation from 35 to 36 m.

The resulting series of velocities will be as follows :

	1st Chronograph.	2d Chronograph.
1st shell	$\nu+\alpha+\beta$	$\nu+\gamma+\delta-\tau$
2nd shell	$\nu'+\alpha+\beta'$	$\nu'+\gamma+\delta'-\tau$
3rd shell	$\nu''+\alpha+\beta''$	$\nu''+\gamma+\delta''-\tau$
…………	…………	…………
The means are	$\frac{\nu+\nu'+\nu''+\ldots}{n}+\alpha$	$\frac{\nu+\nu'+\nu''+\ldots}{n}+\gamma-\tau$,

the sum of the accidental errors being zero, since, by their very definition, they compensate for one another.

The difference between the two means is $\alpha-\gamma+\tau$; if we add it to each of the velocities gotten by the second chronograph, these become:

$$\nu+\alpha+\delta$$
$$\nu'+\alpha+\delta'$$
$$\nu''+\alpha+\delta'$$

thus reducing to what would have been established if the second chronograph had had the same constant error as the first. By subtracting each of these corrected velocities from the corresponding velocity found by the first chronograph, we obtain successively for the corrected differences between the two instruments :

$$\epsilon=\beta-\delta;$$
$$\epsilon'=\beta'-\delta';$$

that is to say, the difference between the corrected readings of the two chronographs is no other than the difference between their accidental errors, each being taken with its proper sign.

The sum of the squares of the corrected differences between the instruments will be:

$$e^2 + e'^2 + e''^2 + \ldots = (\beta - \delta)^2 + (\beta' - \delta')^2 + (\beta'' - \delta'')^2 + \ldots$$

The errors β and δ are as often positive as negative; if we assume, then, a very large number of observations, for each difference $\beta - \delta$ in which β and δ have the same sign, there will be another in which their signs are opposite; in raising these differences to the second power the double products will thus be eliminated, and there will remain simply:

$$e^2 + e'^2 + e''^2 + \ldots = \beta^2 + \beta'^2 + \beta''^2 + \ldots \delta^2 + \delta'^2 + \delta''^2 + \ldots$$

If we represent by ϑ the quadratic mean difference of the instrumental indications,

by ω' the quadratic mean error of the 1st,
by ω'' " " " " 2nd,

the equation above reduces to

$$n\,\vartheta^2 = n\,\omega'^2 + n\,\omega''^2$$

or

$$\vartheta^2 = 2\,\omega^2,$$

ω representing the quadratic mean of the errors of the two instruments.

The mean difference ϑ between the corrected indications of the instruments is also an error, since it would be zero if the instruments were perfect; the equation above, the relation between two quadratic errors, is then also true for the corresponding approximate errors. If we designate by M the approximate mean error of the chronographs, and by N the approximate mean difference between the two corrected indications, we shall be able to write:

$$N^2 = 2M^2, \text{ or } M = \frac{N}{\sqrt{2}},$$

a relation that the law of the composition of errors might have predicted.

Using the data of Appendix III, we find for its successive series:

Series.	Difference between the constant errors of the two chronographs.	Mean of the corrected difference of the velocities registered by the two chronographs.
1	0.62	0.48
2	0.46	0.30
3	0.70	0.89
4	0.37	0.44
5	0.34	0.50
6	0.63	0.33
7	0.80	0.34
Mean	0.56	0.47

The mean accidental error of the chronograph, the distance apart of the targets being 50 meters, and the velocities to be measured about 350 meters, is thus

$$\frac{0.47}{\sqrt{2}} = 0^{m}.33$$

At first sight this result may seem very small to those who have seen two chronographs used at the same time, often showing a discrepancy between their respectively indicated velocities of more than 1 metre. But if we seek the maximum normal difference that may exist between the observed velocities before the elimination of the constant error, we shall find successively: for the probable accidental error of one instrument

$$0.33 \times 0.845;$$

for the probable corrected difference between the velocities of the two instruments

$$0.33 \times 0.84 \times \sqrt{2} = 0^{m}.60$$

and for the maximum limit of the normal differences (limit greater than 96% of the latter differences)

$$0.40 \times 4 = 1^{m}.60.$$

Finally, as in an observation on two instruments, the constant error, which may read 0^{m}.80, will operate to increase the difference between the constant velocities, the difference between the velocities before correction may be so much as 2^{m}.40 without ceasing to be normal.

These deductions are entirely in accord with the data of appendix III; 50% of the corrected velocities differ by less than than 0^{m}.40, and out 70 pairs of duplicate observations two only are abnormal; we have discarded only one of them, the other scarcely being outside the limit—2^{m}.50 difference instead of 2^{m}.40.

The mean error of the chronograph being known, we are able to eliminate it from the mean variations in initial velocity of the 12^{c} and 9^{c} shells, these having velocities of about 350 metres. According to the law of the composition of errors, the mean variation in initial velocity of the 12^{c} shell having been found to be 1^{m}.39 before any correction, the true variation will be

$$\sqrt{(1.39)^2 - (0.33)^2} = 1^{m}.35;$$

and for the 9^{c} shell

$$\sqrt{(1.12)^2 - (0.33)^2} = 1^{m}.08.$$

The correction is then only 0^{m}.04.

When the initial velocity is not 350 metres, the chronograph's error is evidently different, and it would require other series of experiments to determine it. However, calculation will answer the purpose with sufficient accuracy, if the new velocity does not differ much from the first; in fact, the chronograph measuring the time between the targets, the errors occur in this time: if the time varies but little, the mean of the errors will vary but little also. Assuming it constant we shall have: for the calculated velocity v, E being the interval between targets and T the time of passage over this interval,

$$v = \frac{E}{T};$$

and for the variation Δv resulting from a variation ΔT,

$$\Delta v = -\frac{E}{T^2}\Delta T = -\frac{v^2}{E}\Delta T.$$

The errors in velocity due to the chronograph vary, then, directly with the square of the velocity and inversely with the interval between targets.

This formula would be entirely accurate and could always be used, if the targets were set up at an interval proportional to the velocity, which would make the observed time constant.

For the 8ᶜ shell, the velocity is about 380 meters, the mean instrumental error becomes then

$$0^{\text{m}}.33 \times \left(\frac{380}{350}\right)^2 = 0^{\text{m}}.39.$$

The mean variation in the velocity of the 8ᶜ shell thus reduces to

$$\sqrt{(1^{\text{m}}.19)^2 - (0^{\text{m}}.39)^2} = 1^{\text{m}}.13.$$

The correction for errors in velocity not exceeding 5%, is then small enough *for the approximate determination of the chronograph's error to be more than efficient.*

APPENDIX I.

DETERMINATION OF THE TIME OF FLIGHT FOR THE 8c RIFLE.

Table giving results supplied by the ballistic machines.

Numbers of the shots.	RANGES. metres.	Chronograph. — Velocity at 29 m. from the muzzle.	Clepsydra. — Time of Flight.	Date of Firing.
1	1,000	388.22	3.0528	October 29th
2	1,000	390.10	3.0483	October 29th.
3	1,000	389.13	3.0461	October 29th
1	1,200	385.13	3.7830	October 29th
2	1,200	390.72	3.7597	October 29th
3	1,200	389.03	3.7392	October 29th
1	1,400	389.03	4.5003	October 29th
2	1,400	389.02	4.4461	October 31st
3	1,400	389.43	4.4714	October 31st
1	1,600	378.42	5.2257	November 7th
2	1,600	379.55	5.2330	November 7th
3	1,600	376.78	5.2197	November 7th
1	1,800	391.08	5.9966	November 4th
2	1,800	379.08	6.0180	November 6th
3	1,800	376.82	6.0473	November 6th
1	2,000	372.43	6.7970	November 3rd
2	2,000	370.91	6.7318	November 3rd
3	2,000	373.82	6.7636	November 3rd

APPENDIX II.

DETERMINATION OF TIME OF FLIGHT FOR THE 12c STEEL RIFLE.

Weight of charge $1^k.450$. *Weight of Projectile* $14^k.390$.

Numbers of the shots.	Time of Flight in Seconds.	Remarks.
1	3.0912	Firing done on April 20th, at 1,000 meters. Distance from muzzle to the first target, 9^m. Interval between targets, 988^m. Odd-numbered shots fired from piece No. 57. Even-numbered shots fired from piece No. 4.
4	3.1035	
5	3.1055	
6	3.1039	
8	3.0795	
10	3.1269	
13	3.1567	
15	3.1267	
16	3.1344	
18	3.1273	
19	3.1026	
20	3.1192	
1	3.1249	Firing done on August 21st, at 1,000 meters. Same remarks as given above under date of April 20th.
2	3.1289	
3	3.1129	
5	3.0894	
7	3.1207	
8	3.1197	
9	3.1133	
10	3.1220	
11	3.1239	
12	3.1144	
16	3.1368	
18	3.1275	

APPENDIX III.

Ballistic Practice with a 12° Steel Gun.

Series.	Distance from breech block to base of projectile.	Calculated Velocity.	
		35 m. from muzzle.	36 m. from muzzle.
I.	II.	III.	IV.
	mm.	m.	m.
1st.	486.1	349.4	349.0
	482.8	349.3	349.4
	484.3	348.4	347.3
	480.4	353.5	352.6
	485.1	348.6	348.6
	483.0	351.6	350.6
	482.3	350.6	350.0
	481.7	351.0	349.1
	482.1	349.8	349.5
	484.6	347.8	347.7
2nd.	482.8	350.3	350.2
	481.1	351.4	350.9
	482.4	348.6	348.4
	484.7	348.4	347.7
	483.0	348.2	347.5
	481.7	351.5	350.5
	482.5	349.6	349.0
	480.3	350.7	349.9
	482.1	349.1	349.1
	483.8	348.4	348.4
3rd.	480.6	351.4	351.3
	483.2	350.4	349.9
	482.5	348.6	350.6
	480.7	352.5	351.6
	484.1	349.9	345.9
	481.9	352.4	350.8
	484.6	348.1	347.6
	482.7	349.6	348.0
	480.0	354.8	352.3
	481.8	347.4	347.2
4th.	485.4	350.3	350.8
	482.9	351.5	350.4
	483.6	351.7	351.4
	485.8	347.0	346.9
	482.3	350.4	349.8
	486.8	348.3	347.4
	484.1	351.4	351.3
	484.9	349.8	348.8
	484.3	347.7	348.0
	486.2	348.6	348.4
	481.9	350.2	350.2
5th.	481.4	350.4	350.0
	483.5	349.8	348.7
	485.3	350.6	350.0
	485.2	348.6	347.5
	480.9	350.6	350.4
	484.6	349.7	350.0
	480.1	350.5	349.5
	482.2	348.4	348.5
	483.3	349.5	349.7
	480.2	352.0	352.4
6th.	481.4	351.2	351.0
	484.5	351.6	350.3
	481.3	352.6	351.7
	484.4	349.8	349.4
	483.0	350.4	349.8
	483.0	348.4	347.4
	483.3	352.0	351.9
	484.5	349.0	348.4
	480.9	350.3	350.1
	483.8	352.4	351.4
7th.	486.1	351.0	351.0
	482.1	350.5	349.6
	481.7	350.5	349.0
	482.1	348.7	348.0
	482.1	350.0	349.0
	480.1	351.6	350.5
	485.2	349.4	348.5
	486.5	346.4	345.6
	480.9	350.0	349.9
	484.4	347.6	347.2
	483.1	349.7	348.6

APPENDIX IV.

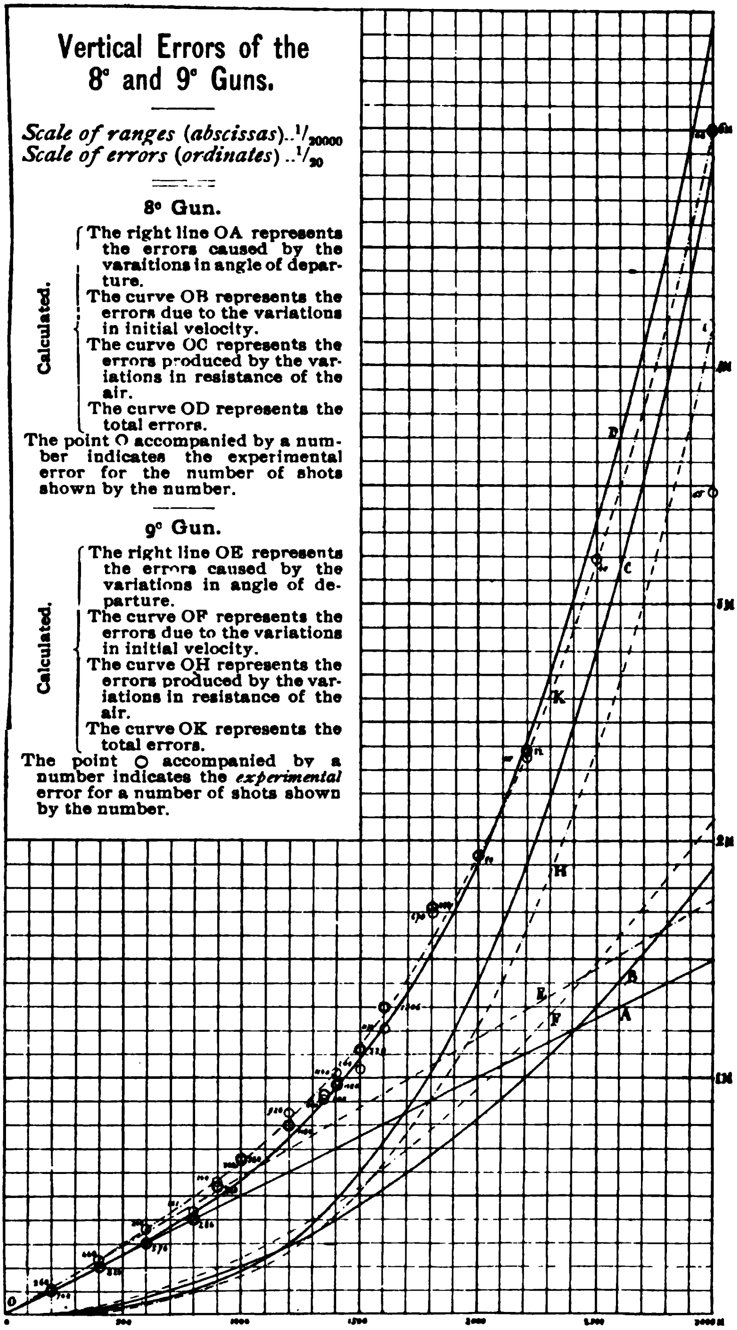
MEAN ERRORS DETERMINED IN SHELL FIRE, WITH HEAVY CHARGE, OF 8^c AND 9^c GUNS.

Range.	8^c Gun.			9^c Gun.		
	Number of Shots.	Mean Error.		Number of Shots.	Mean Error.	
		Vertical.	In Range.		Vertical.	In Range.
metres		metres	metres		metres	metres
200	740	0.10	0.10	260	0.123	0.137
400	824	0.20	0.20	460	0.229	0.282
600	576	0.30	0.35	240	0.36	0.44
800	286	0.40	0.50	161	0.43	0.62
900	320	0.54	0.68	144	0.56	0.78
1000	380	0.66	0.87	360	0.65	0.73
1200	1186	0.80	1.02	926	0.85	1.06
1350	400	0.93	1.19	400	0.91	1.33
1400	1380	0.97	1.15	1140	1.02	1.21
1500	320	1.12	1.17	144	1.04	1.40
1600	1306	1.30	1.55	1176	1.21	1.49
1800	490	1.72	1.61	670	1.70	1.59
2000	94	1.94	3.02	670	1.70	1.59
2200	82	2.38	2.41	111	2.35	1.94
2500	82	2.38	2.41	40	3.19	2.18
3000	66	5.01	2.41	65	3.47	3.56

N. B.—The shots at ranges above 2000 metres are experimental shots, fired in weather that was unfavorable.

GENERAL DONNY.

PLATE I.



Vertical Errors of the 8" and 9" Guns.

Scale of ranges (*abscissas*)..$^1/_{20000}$
Scale of errors (*ordinates*)..$^1/_{20}$

8" Gun.

Calculated.
- The right line OA represents the errors caused by the varaitions in angle of departure.
- The curve OB represents the errors due to the variations in initial velocity.
- The curve OC represents the errors produced by the variations in resistance of the air.
- The curve OD represents the total errors.

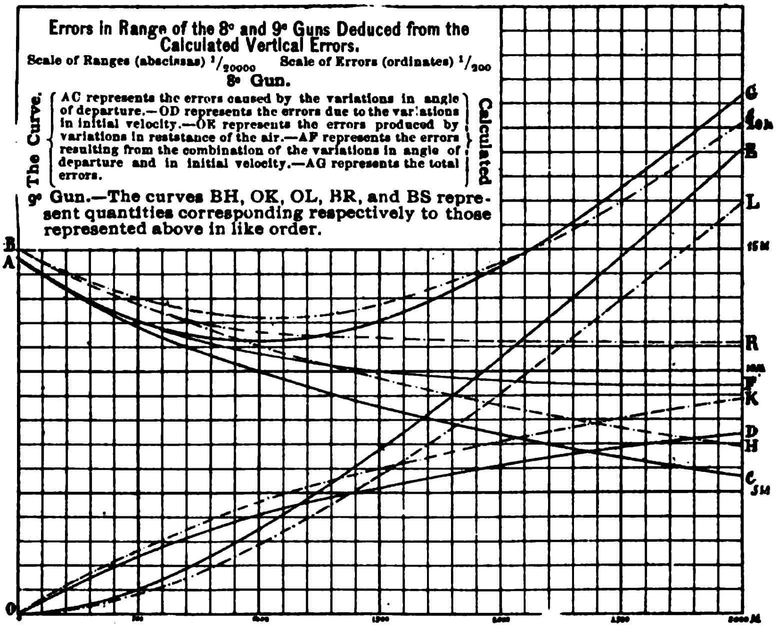
The point O accompanied by a number indicates the experimental error for the number of shots shown by the number.

9" Gun.

Calculated.
- The right line OE represents the errors caused by the variations in angle of departure.
- The curve OF represents the errors due to the variations in initial velocity.
- The curve OH represents the errors produced by the variations in resistance of the air.
- The curve OK represents the total errors.

The point O accompanied by a number indicates the *experimental* error for a number of shots shown by the number.

PLATE II.



Errors in Range of the 8° and 9° Guns Deduced from the Calculated Vertical Errors.

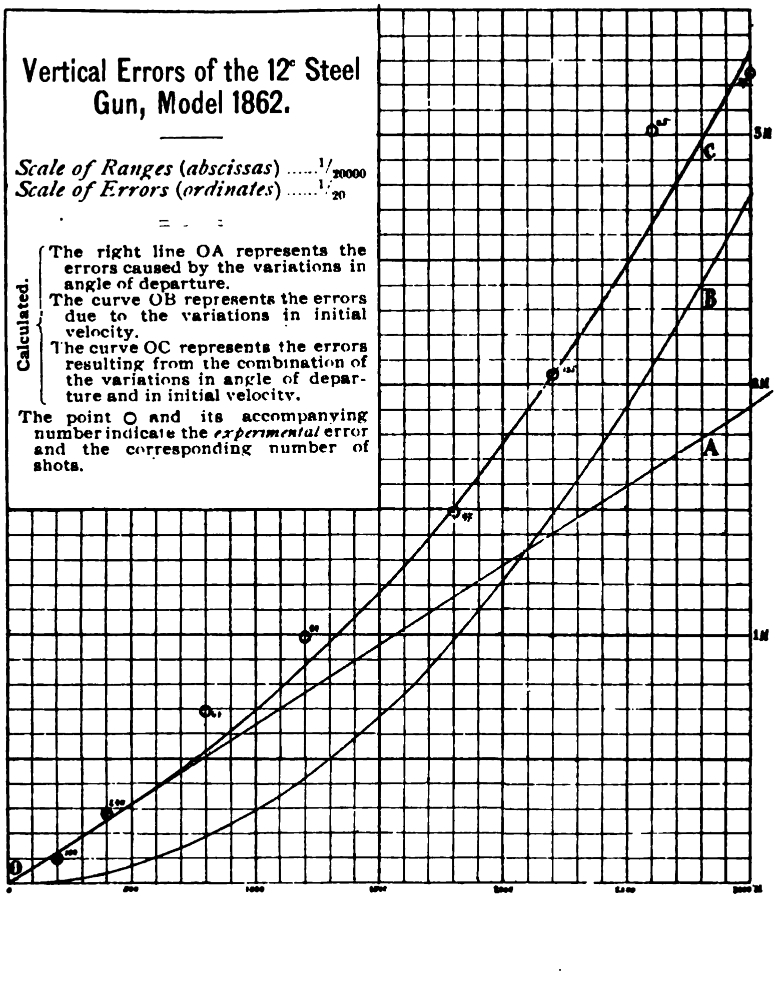
Scale of Ranges (abscissas) $^1/_{20000}$ Scale of Errors (ordinates) $^1/_{200}$

8° Gun.

The Curve. AC represents the errors caused by the variations in angle of departure.—OD represents the errors due to the variations in initial velocity.—OE represents the errors produced by variations in resistance of the air.—AF represents the errors resulting from the combination of the variations in angle of departure and in initial velocity.—AG represents the total errors. Calculated

9° Gun.—The curves BH, OK, OL, BR, and BS represent quantities corresponding respectively to those represented above in like order.

PLATE III.



Vertical Errors of the 12c Steel Gun, Model 1862.

Scale of Ranges (*abscissas*) 1/20000
Scale of Errors (*ordinates*) 1/20

Calculated.

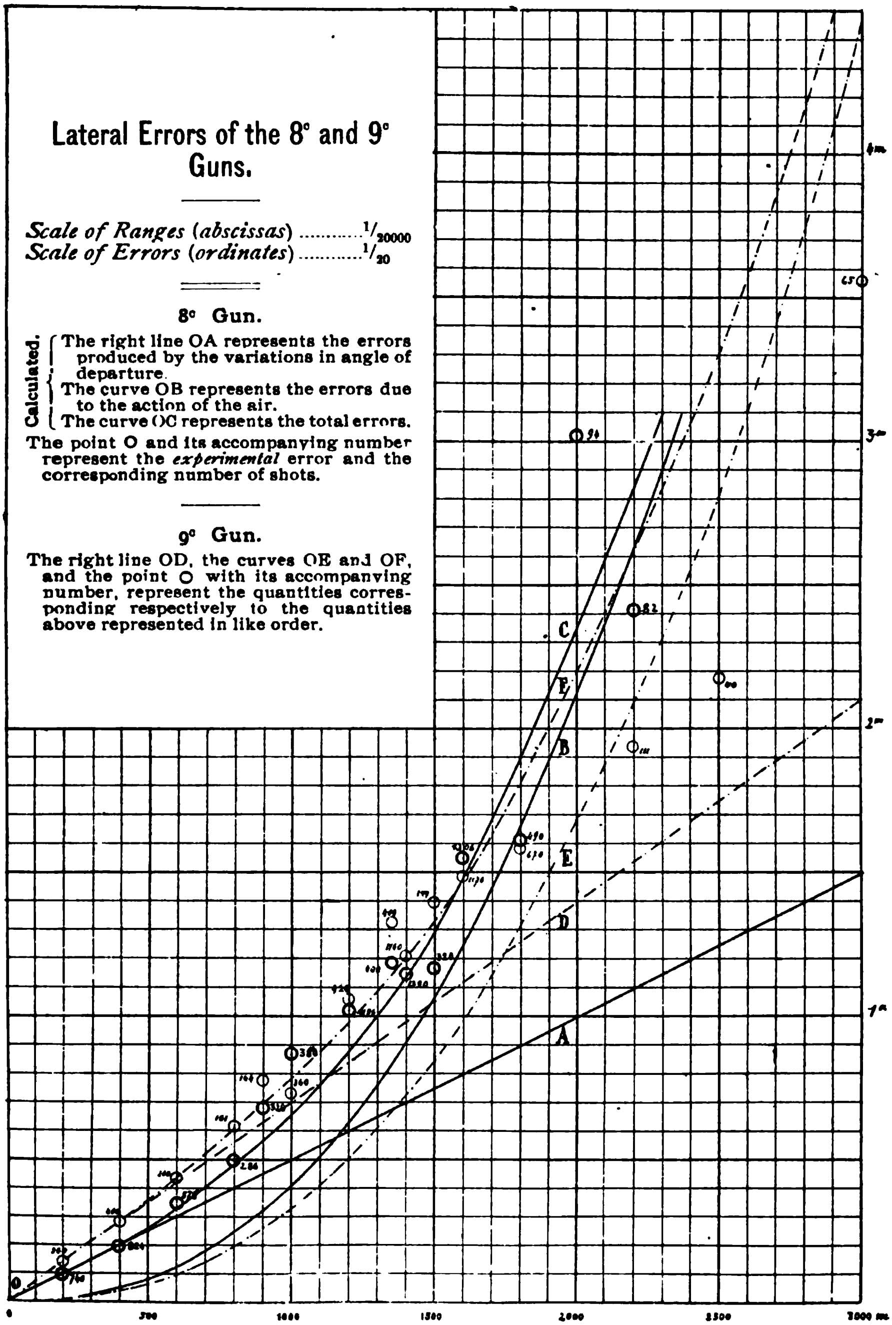
The right line OA represents the errors caused by the variations in angle of departure.

The curve OB represents the errors due to the variations in initial velocity.

The curve OC represents the errors resulting from the combination of the variations in angle of departure and in initial velocity.

The point ○ and its accompanying number indicate the *experimental* error and the corresponding number of shots.

PLATE IV.



Lateral Errors of the 8c and 9c Guns.

Scale of Ranges (*abscissas*) .... $^1/_{20000}$
Scale of Errors (*ordinates*) .... $^1/_{20}$

8c Gun.

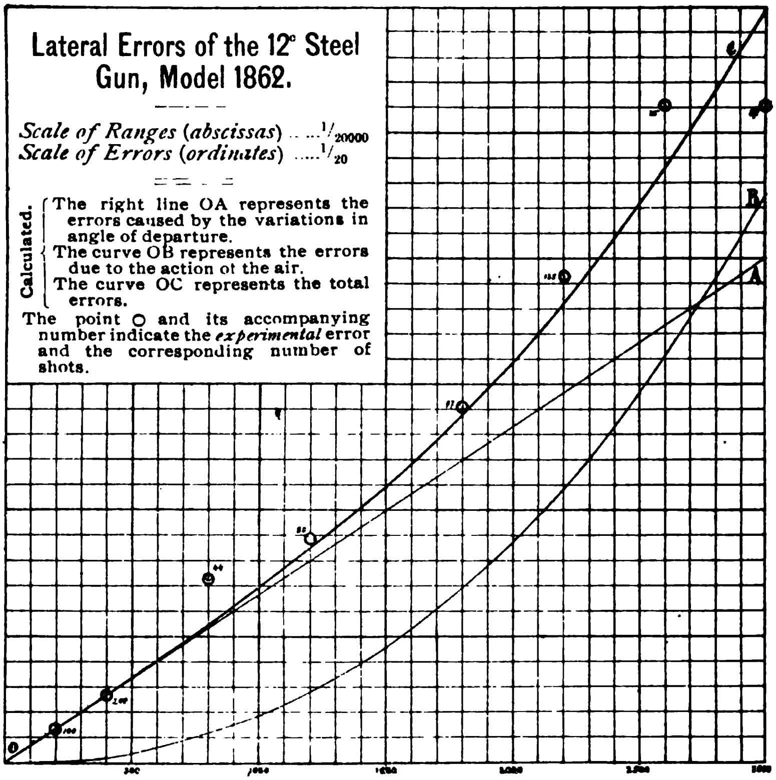
Calculated.
- The right line OA represents the errors produced by the variations in angle of departure.
- The curve OB represents the errors due to the action of the air.
- The curve OC represents the total errors.

The point O and its accompanying number represent the *experimental* error and the corresponding number of shots.

9c Gun.

The right line OD, the curves OE and OF, and the point O with its accompanying number, represent the quantities corresponding respectively to the quantities above represented in like order.

PLATE V.



Lateral Errors of the 12^c Steel Gun, Model 1862.

Scale of Ranges (abscissas) ...... $^1/_{20000}$
Scale of Errors (ordinates) ..... $^1/_{20}$

Calculated. The right line OA represents the errors caused by the variations in angle of departure. The curve OB represents the errors due to the action of the air. The curve OC represents the total errors.

The point ○ and its accompanying number indicate the *experimental* error and the corresponding number of shots.

THE COMPILATION OF RANGE TABLES.

BY MAJOR H. P. HICKMAN, R. A.

Reprinted from the *Proceedings of the Royal Artillery Institution*, July-August, 1901.

Before going into details of the methods pursued in the compilation of range tables, it may be as well to at once point out that a range table can only be taken as a guide, and to state as briefly as possible why this must be so, and in doing this to indicate the points that have to be attended to in the compilation of the range table to ensure its being, as far as possible, a good average guide.

The following is a consideration of the causes which may lead to difference between the shooting of a gun when fired, say, at annual practice and the shooting of a gun of the same nature in the practice on which the range table has been based, and each cause will be discussed separately.

(*a.*) *Wear of Gun.*

All guns, whether fired with cordite or powder, suffer more or less from wear, and consequent enlargement in the diameter of the bore at and about the commencement of the rifling, and this causes a gradual falling off in the muzzle velocity obtained in the gun, according to the number of rounds and the nature of the charges that have been fired from it. With cordite the wear is very much less with reduced than with full charges, but it is an unfortunate fact that the effect of wear on the ballistics is much greater with reduced than with full charges—owing probably to the falling off in chamber pressures (with results from wear) having a more serious effect on the time of burning of the cordite in the reduced charge.

Wear, and consequent falling off in velocity, is greatest when a gun is quite new, and gradually gets less and less per round; it follows that, if it can be avoided, a new gun should not be used for range table practice, and a gun which is about one quarter worn (that is which has fired about one quarter of the total number of rounds which it may be expected to fire before being sentenced for repair) is, as far as may be possible, always chosen for the purpose.

It may here be observed that in the smaller calibers the wear and consequent loss of velocity is very slight, and in the heavier natures the introduction of composite charges has proven of immense benefit, as the ballistics with these charges, especially in the case of reduced charges, are found to be much less influenced by the effects of wear.

It will also be noticed that a gun cannot be expected to shoot in absolute accord with the range table unless it has previously fired the same number of rounds as had the gun which was used for the practice on which the range table was based.

(*b.*) *Ballistics of the Lot of Cordite used.*

Any two Lots of cordite or gunpowder (of any given nature) now in the Service may differ in the muzzle velocity that they will give by as much as 50 feet per second. The cordite used at Shoeburyness is specially selected as being at the mean of the specification, but it will be seen that a Lot may be used in practice giving a different muzzle velocity from the range table.

(*c.*) *Temperature of Cordite Charge.*

The temperature of the charge has a considerable effect on the ballistics, an increase in temperature increasing the ballistics and *vice versâ*, and as the charges used in practice at Shoeburyness are carefully heated to 60° Fahr., any variation from this will affect the results of practice: the effect of temperature of charge is more pronounced in worn than in new guns, and is also greater with reduced than with full charges.

(*d.*) *Temperature of the Air.*

The effect of this is twofold; it is generally supposed to affect the muzzle velocity, though actual proof is wanting, and it has been estimated to be about half the effect of (*c*), but until more accurate knowledge is gained on this point no allowance can be made. The effect of temperature on the density of the air is of course known, and as it affects the resistance to the flight of the projectile, the ranges obtained in practice will differ from those obtained in the practice on which the range table was compiled by an amount depending on the difference in the temperature of the air in the two cases.

(*e.*) *Height of Barometer.*

(*f.*) *Humidity of the Air.*

Both of these affect the resistance of the air, and consequently the range attained for any given elevation, and therefore, unless the conditions are the same as those under which the range table was compiled, the same results are not to be expected. The practice at Shoeburyness is carried out under the most favorable atmospheric conditions possible, and it is seldom that the latter are so abnormal as to necessitate any large correction being made in preparing the range table.

(*g.*) *The Projectile.*

The range table is made out for the most important projectile for the gun, and it does not follow that the other projectiles in its equipment will necessarily range the same, though the difference is no doubt small as a general rule. Thus a common shell fitted with a percussion fuse must encounter more resistance from the air than a pointed common shell.

The projectiles used in range table practice are carefully weighted so as all to be identical in weight, while those in the Service differ between each other by amounts depending on the manufacturing limit allowed, and, in the case of practice projectiles, depending on the care exercised in filling them with salt.

(*h.*) *Wind.*

This must be an ever present source of difference between the results of practice and those to be expected from the range table.

(*i.*) *Jump.*

This can only be ascertained at low angles of elevation, and it is not known how it may vary at high angles, or at angles of depression in the case of guns mounted on high sites. It is known to vary slightly in different guns and in different mountings of the same nature, and ts therefore another element of uncertainty, though it is not believed to be a canse of any serious discrepancies in shooting, especially in the case of the newer mountings with axial recoil.

The extent to which the foregoing causes of discrepancies may be expected to influence the results of practice, as compared with what might be expected from the range table, will be considered under various headings in the following pages.

BALLISTIC TABLES.

The ballistic tables which we usually employ are based on Professor Bashforth's original experiments, but as these were carried out with projectiles having heads with an ogive of 1½ calibers radius, it will be borne in mind that it is necessary to employ a suitable coefficient of reduction when dealing with projectiles differing from those used in the experiments. The formulas we use are Siacci's for flat tracjectories and Mayevski's modified forms of them for angles of departure above 5°; in using the former, Table VI. in the pamphlet (1897) by A. G. Hadcock, Esq., will be found of very great assistance.

Colonel Ingalls ot the United States Artillery, has recently published a new set of tables (dated 30th April 1900), which are of great value in reducing the labor involved in calculations by

Siacci's formulas, but it is important to remember that the laws of resistance adopted for these tables were deduced from the Krupp firings made at Meppen in 1881 for velocities less than 700 meters per second, and since extended by Colonel Zaboudski to include higher velocities, and that in using these tables for our pointed B. L. shells they should give approximately correct results, using a coefficient of reduction of *unity;* this is speaking only of direct fire with guns up to about 10° of elevation: at elevations above this the calculated ranges exceed those obtained in practice with our projectiles. To be more precise, these tables will be found to give correct results up to the elevation mentioned with projectiles for which a coefficient of reduction of ·896 gives correct results when working with our ballistic tables and Siacci's formulas, and this affords a means of using them when making calculations for projectiles having any other coefficient if we happen to know it (in this connection, *see* remarks on *Coefficient of reduction.*

Thus, if we know that with any given gun $\kappa\sigma = 0 \cdot 97$ gives good results with Siacci's formulas and our tables, we should find that practically the same results are obtained with Ingalls' tables (up to angles of departure of 10° or 15°) by using the following value—

$$C = \frac{w}{0 \cdot 97 \times d^2} \times 0 \cdot 896.$$

The following example is given to show the comparative results when working by Siacci's methods and Ingalls' for a flat and curved trajectory respectively, which the reader can work out for himself, using Mayevski's modified formulas in the 20° series; the example is from actual practice :—

Gun—4-inch Q. F.
M. V.—2,237 f. s.
Barometer—29 · 97 inches.
Thermometer—65° Fahr.
Weight of shell—25 lb.

(*a.*) $\varphi = 5°$. Range obtained 4,360 yards, time of flight 9 · 75 seconds. Take $\kappa\sigma = 0·83$ (to work by Siacci's method).

$$\log f \frac{w}{\tau d^2} = 0 \cdot 2065$$

$$\log 0 \cdot 83 = \bar{1} \cdot 9191$$

$$\log C = 0 \cdot 2874$$

Working by Siacci's formulas for direct fire we find—

$$R = 4{,}358 \text{ yards.}$$

Now, working with Ingalls' tables, we must multiply the former value of C by 0·896,

$$\log C = 0\cdot 2874,$$
$$\log 0\cdot 896 = \bar{1}\cdot 9523,$$

from which the new log C to work with

$$= 0\cdot 2397,$$

and with this we obtain

$$R = 4{,}345 \text{ yards},$$

which is very nearly what was obtained by the other method and agrees closely with practice.

(*b.*) $\varphi = 20°$. Range obtained was 9,090 yards, $t = 30\cdot 7$ seconds. Taking the same value for $\kappa\sigma$, viz., 0·83, and finding the altitude correction from the time of flight as explained further on,

$$\log C = 0\cdot 3225$$

for working by Siacci's method, and using the modified formulas for curved fire, we obtain

$$R = 9064,$$

which is within 23 yards of the actual range.

To work with Ingalls' tables, applying the same correction to C as before, we get

$$C = 0\cdot 2748$$

and $$R = 9{,}224 \text{ yards},$$

which is too great.

From the above considerations, therefore, the writer prefers to work by Sacci's methods and our tables, with which the agreement between theory and practice has been found in a very large number of examples which have been worked out to be most remarkable. Indeed, it is necessary to work by Siacci's method with most of the range tables that have to be prepared for *guns*, as the elevations frequently extend to 20° and even more, and Ingalls' tables, in many instances, do not extend sufficiently far to deal with such elevations, and, as has been stated, do not give results in agreement with practice at such high elevations with our projectiles.

With howitzer range tables it is another matter, as for high angle fire and low velocities we cannot use Siacci's methods and our tables, and Captain Ingalls' tables are invaluable for the purpose, and give very good results as compared with practice. It is necessary to make use of Siacci's function β in connection with the tables.

The Ballistic Coefficient.

The ballistic coefficient, C, is

$$f\cdot\frac{w}{\tau\,.\,\kappa\sigma\,.\,d^2}$$

In this expression

w = Weight of projectile in pounds.
d = Diameter " " inches.
*f (or $\frac{\delta}{\delta^1}$) = A factor for correcting for the reduced density of the atmosphere in the upper portion of the trajectory.
τ = A factor for correcting for variations in height of barometer and thermometer when these differ from the normal.
$\kappa\sigma$ = The "coefficient of reduction."

Here d is given as the diameter of the projectile, but the proper dimension is the diameter of the driving band after it has been engaged by the rifling; and d may therefore be taken practically as the diameter of the bore of the gun.

f. This is the symbol we shall employ for expressing the correction to be applied for the density of the atmosphere at a height equal to $\frac{3}{8}$ the height of the maximum ordinate of the trajectory, then

$$f = e^{\frac{\frac{3}{8}h}{\lambda}}$$

where h is the maximum ordinate in feet, and from which

$$\log(\log f) = \log(\log e) - \log\lambda + \log\tfrac{3}{8}h.$$

Taking the usual value of λ (*see* Text Book of Gunnery), this may be reduced to the convenient expression

$$\log(\log f) = \bar{5}\cdot 0176 + \log h\dagger$$

for finding the value of $\log f$ for $\frac{3}{8}h$.

The maximum ordinate, h, must first be found. When the time of flight, T, is known, $4\,T^2$ for the height in feet gives a very close approximation; but in basing a range table on calculation the problem becomes more laborious, unless, indeed, we have Ingalls' tables, which contain an extremely simple and accurate solution by means of his A′ and A″ columns. Failing these we must fall back on the formula

---

* Ingalls uses f for this factor, and our Text Book of Gunnery, 1897, uses $\frac{\delta}{\delta_1}$; to save confusion we shall adopt the former in subsequent pages, as Ingalls uses the latter for another factor.

† This equation was first given by Lieut. Col. Ingalls in his *Handbook of Problems in Direct Fire*. New York. 1890. Page 307. Also *Artillery Circular N*, page 42. J. M. I.

$$\frac{y_0}{x_0} = \tan\varphi - \mathrm{C}\sec\eta\left\{\mathrm{I}(\mathrm{U}) - \frac{\mathrm{A}(\mathrm{U}) - \mathrm{A}(\mathrm{u})}{\mathrm{S}(\mathrm{U}) - \mathrm{S}(\mathrm{u})}\right\}$$

This is a fairly long calculation, and having found a first value for y_0, C must be corrected accordingly and the calculation repeated, doing this a third time with the corrected value of C if great accuracy is required.

This is very laborious, and the following formula (which is *purely empirical*) is put forward as a simple one for obtaining a first approximation to the value of y_0 from which to obtain log f,—

$$y_0 = \frac{w}{\tau\,.\,\kappa\sigma\,.\,d^2}\cos\eta\,\sin\left(\tfrac{2}{3}\psi\right)\left\{\mathrm{S}(\mathrm{U}) - \mathrm{S}(\mathrm{u}_0)\right\}$$

The following example is given, (1) when the time of flight is known, (2) when it is not. The example is from actual practice :—

Example : Gun = 6-inch B. L.

M. V. = 2,495 f. s.

$\psi = 15^\circ\ 5'$.

$\log\dfrac{w}{\tau\,.\,\kappa\sigma\,.\,d^2} = 0 \cdot 5041$.

$\left.\begin{array}{l}\mathrm{R} = 11{,}000 \text{ yds.}\\ \mathrm{T} = 27 \cdot 5 \text{ secs.}\end{array}\right\}$ observed.

Find an approximate value of log f.

(*a.*) *Knowing the time of flight :*

log T = 1 · 4393

log T^2 = 2 · 8786

log 4 = 0 · 6021

∴ log y_0 = 3 · 4807 (3,025 feet).

Constant log = 5 · 0176

log (log f) = 2 · 4983

log f = 0 · 0315

(*b.*) *Time of flight and range unknown :*

Employing the usual formulas for curved fire we have the mean angle $\eta = 8^\circ\ 51'$ and U = 2,439 f. s., and using the value of log C given in the data with the formula—

$$\tan\psi = \mathrm{C}\sec\eta\left\{\mathrm{I}(\mathrm{U}) - \mathrm{I}(\mathrm{u}_0)\right\}$$

we obtain u_0 = 1,070 f. s., and employing the proposed new formula,—

S (U) = 46578 · 3

S (u_0) = 40650 · 5

S (U) − S (u_0) = 5927 · 8

log{ " " } = 3 · 7729

log C = 0 · 5041

$$
\begin{aligned}
\log \cos \eta &= \bar{1}\cdot 9948 \\
\log \sin (\tfrac{2}{3}\phi) &= 1\cdot 2411 \\
\hline
\log y_0 &= 3\cdot 5129 \text{ (3,257 feet).} \\
\text{Constant } \log &= 5\cdot 0176 \\
\hline
\log (\log f) &= 2\cdot 5305 \\
\log f &= 0\cdot 0339
\end{aligned}
$$

It will be observed that in the calculations in (*b*) we have already found the values of η, U, I (U), and S (U) for use in the further calculations with the *proper* formula for finding y_0, and if we now proceed with these calculations using the value of log *f*, just found, we shall find that the true height is 3,252 feet, which is in remarkable agreement with that found in (*b*), while the value found in (*a*) is sufficiently close for practical purposes.

The proposed formula will not always give such a close approximation as in this particular case, but in very few cases will it be found to give results differing appreciably from the proper value for log *f*.

The Coefficient of Reduction, $\kappa\sigma$.

On a correct estimate of the value of this factor depends the exactness of calculations connected with external ballistics. It is introduced in order to correct the results given by the ballistic tables when a projectile is used which differs from those used in the experiments for obtaining the data on which these tables were based ; the latter had the ogive of the head struck with a radius of 1½ diameters, whereas most modern projectiles have 2-diameter ogives, though this is discounted to some extent in common and shrapnel shells intended for nose fuzes, and our shrapnel shells for field guns have 1½-calibre heads, the adverse effect of which is, in turn, probably mitigated to some extent by the time fuze.

Siacci has pointed out that by making the "coefficient of reduction" 0·896 his resistance formula gives results agreeing with those of the experiments made by Hojel and Krupp, and, speaking generally, this value gives approximately correct results in calculations with our pointed projectiles ; but so much depends on the particular design of the shell, driving band, and the rifling of the gun, as well as on the velocity, that it is impossible to lay down any hard-and-fast rule.

The following values of $\kappa\tau$ are given for what they are worth, and will be found of use as a general guide. They are the result of a large number of calculations from selected practice reports, in which the data has appeared to be the most reliable, though it has been difficult in all cases to select ones in which the wind was entirely negligible as regards force and direction. The necessary corrections have, of course, been invariably made for atmospheric pressure when it differed from the normal, and the correction for altitude was taken as that for $\frac{2}{3}$ the maximum ordinate :—

TABLE OF VALUES OF $\kappa\sigma$ FOR VARIOUS GUNS AND PROJECTILES.

Nature of Gun.	Muzzle Velocity. f. s.	Nature of Projectile.	Radius of Ogive of Head of Projectile.	Value of $\kappa\sigma$ for Angles of Departure of about 2° to 5°.	Remarks.
12-inch Mark IX	2,434	Pointed common shell.	2 diameters	·91	
	2,067			·87	
	1,583			·78	
12-in. Mark VIII	2,381			·91	
	1,863			·83	
9·2-inch	2,601			·91	
	2,347			·89	
	2,196			·86	
	2,127			·86	
	1,770			·85	
	1,631			·80	
	1,408			·80	
6-inch Mark VII	2,493			·87	
6-inch Mark IX	2,498			·89	
5-inch	1,890			·90	
4·7-inch Q. F. Mark IV.	2,187	Common, fitted for nose fuse.	2 diameters	·88	
4·7-inch Q. F. Mark V.	2,410	Pointed common.	2 "	·90	
4-inch Q. F.	2,237	" "	2½ "	·83	
4-inch B. L. (30 pr.)	1,621	Shrapnel with time fuse.	2 "	·86	Service type of T. and P. fuse.
15-pr. B. L.	1,581	" "	1½ "	·97	" "
15-pr. Q. F.	1,609	" "	2 "	·87	Fuse forming correct ogive with head.
10-pr. B. L.	1,300	" "	1½ "	·97	Service type of T. and P. fuse.

The remarkable diminution of the value of $\kappa\sigma$ in accordance with the fall in velocity in the heavy guns will be noticed. All the comparatively recent practice from 9·2-inch guns was therefore worked out to confirm this, and the results are given.

There is very little data to form any direct comparison between the coefficient for a pointed and truncated common shell. The two 4·7-inch guns are not comparable, but it is believed, from such data as is available, that the coefficient differs but slightly in the two natures of shells, and, if one were to hazard an opinion, the relation between the coefficients for pointed and truncated shells might be taken roughly as 90 to 92.

The evil effect of the 1½ diameter head is noticeable in the 15-pr. B.L. and 10-pr. shrapnel; it is not thought that our form of time and percussion fuze is at all prejudicial, and indeed in these cases it appears to have improved matters, as the usual coefficient for 1½-calibre head is unity; this view is also confirmed in the case of the 4-inch B.L. 30-pr., which has a very good coefficient, though it has a similar fuze to the 15-pr., but a shell with 2-diameter head.

The fact of the radius of the head of the shell in the 15-pr. being 1½ instead of 2 diameters is responsible for a loss of about 150 yards in range at 15° elevation, and the writer is prepared to go further and to suspect it of being a cause of inaccuracy.

It will generally be found in working Siacci's formulas, and the modified forms of them, that, as the angle of departure increases above about 10°, a lower value of $\kappa\sigma$ has to be taken to make the range obtained by calculation agree with that found in practice; this remark, however, is strictly confined to velocities above 1,200 f.s. (as far as a limited experience permits of a definite figure being hazarded), and to angles of elevation not exceeding 40°. There are occasional exceptions to this rule, notably the 4·7-inch Q.F. guns, with which one value of $\kappa\sigma$ gives good results at all angles of departure up to 20°.

For lower muzzle velocities, as with howitzers, the opposite is the case, and it will be found necessary to take an increased value for $\kappa\sigma$ as the angle departure increases. Siacci has introduced his function β (*see* Table I.) to correct for these vagaries in the coefficient of reduction (which has to be *multiplied* by β), and it will be found of great use in approximating to the proper value of $\kappa\sigma$ to employ at high angles of elevation when a value has once been obtained which gives correct results for low angles; its use is obviously limited to cases, as in range table work, when the actual range given by a gun at any elevation is known, and the values assigned by Siacci in the table bear out the writer's experience as to the manner in which the $\kappa\sigma$ varies with the angle of departure at different muzzle velocities; thus, in the example of the 15-pr. Q.F. gun given further on, the values of $\kappa\sigma$ found to give correct results at the long ranges agree fairly with those found by multiplying the value obtained from the remaining volocities at 500 yards by β as taken from Table I.

The 6-inch Mark IX. gun given in the table of $\kappa\sigma$ has too high a muzzle velocity to come within the scope of Siacci's table of $\bar{\beta}$, but the following values of $\kappa\tau$ were found to give correct results. The reader will be careful to bear in mind that these and all calculated values for the coefficient of reduction are based on the assumption that the corrections for altitude and for the density of the atmosphere are *accurate* ones, which is not by any means *necessarily* the case; thus, taking the mean density as that at $\frac{2}{3}$ of the maximum ordinate cannot be more than an assumption, and may not be entirely correct, while τ contains no correction for moisture in the air when that varies from the normal. $\kappa\sigma$ might really be called "a coefficient to correct for erroneous assumptions."

ϕ (Approximate.)	R (Approximate.) Yds.	$\kappa\sigma$
5°	6,000	·89
9°	8,450	·88
15°	11,000	·86
17° 30′	12,000	·85

(*See also* the varying values for the 15-pr. Q.F. further on.)

Mr. Bashforth, in a pamphlet published in 1900, contends that the fact that the calculated ranges at the higher angles of departure are less than the actual ones, is due, not to any errors in the tables or in the data on which they are based, but to the "kite-like" motion of the projectile due to the vertical component of the resistance of the air, and which tends to make the range greater than it would be if the only influence were the resistance to motion determined in the ballistic experiments. If this view were correct one would expect to find that the discrepancy between theory and practice at high angles of departure was greater in the case of relatively long projectiles than with short ones; as a matter of fact, the calculated ranges for the 4-inch Q.F. gun, which has a very short projectile, agree with those found in practice for all elevations up to 20°, using the same coefficient (·83) throughout, and the same is practically the case with the 5-inch and 4·7-inch, which have also comparatively short projectiles.

So far as it goes, therefore, the evidence appears to be in support of Mr. Bashforth's theory, but there are also other considerations, such as the position of the center of gravity and the radius of gyration of projectiles, which probably affect the question. In any case, the remarkable agreement between the results of calculation and those obtained in practise, *when a coefficent suitable to the gun and projectile is employed*, shows that the original data obtained by Mr. Bashforth so many years ago, and on which our tables are based, leave little to be desired at the present day with modern projectiles.

The reader will bear in mind that there are considerations of rifling, driving bands, state of wear of the bore of the gun, clearance between bore and projectile, etc., etc., which all affect the question of *steadiness* of projectiles, and the table of values of $\kappa\sigma$ must be discounted accordingly, and not taken as more than a general guide.

τ. *Oorrection for Density of the Atmosphere.*

This correction is made in accordence with the table given in the Text Book of Gunnery. The normal or standard density is when the barometer is 30 inches, the thermometer 62° Fahr., and the air is two-thirds saturated with moisture; the tabie affords the means of determining the value of τ when the former vary, but not for variations in the moisture in the air.

An example of the effect of variations in the density of the atmosphere is given on page 173.

Method of carrying out Practice to obtain Data for compilation of Range Tables.

The following is a typical programme of practice :—

"*To be carried out at Shoeburyness.*

"Series I. Fire as follows with shrapnel shells fitted with burnt-out time and percussion fuzes :—

"(*a*) 6 rounds with charges at 60 degrees Fahr., at a light card-board target at 500 yards range, for muzzle velocities, jump and accuracy. Remaining velocities at 500 yards to be also taken in the last 5 rounds.

"(*b*) 6 rounds at each of the following angles of elevation for range and accuracy, with charges at 60 degrees Fahr. :— 2 degrees, 5 degrees, 8 degrees, 12 degrees, and maximum.

"Noting ranges and times of flight.

"Series II. Fire, with filled shrapnel shells fitted with time and percussion fuzes, 6 rounds with fuzes set at each of the following graduatlons:—

5, 9, 14, and 18.

"Noting times of burning."

Full particulars of the ammunition to be used are given in the programme, and before it is carried out the following points should, in all cases, be strictly attended to by the Officer carrying out the trial:—

(1.) The gun will, as a rule, be specially provided for the programme, and it should be ascertained that it is in a serviceable condition and in all respects suitable, especially as regards the state of the bore; it should have fired as nearly as possible one quarter the number of full charges which constitute the estimated life of the rifling before repair is required.

The clinometer plane should invariably be tested to ascertain whether it is parallel to the axis of the bore *at the muzzle;* should there be any difference a corresponding allowance must be made in the elevation given during the practice. If there is no clinometer plane a demand must be put forward to have one cut.

The sights should be checked to ascertain that when set at zero the line of sight is parallel, in the verticle plane, with the axis of the bore at the muzzle, any difference being corrected for in laying for line; the usual procedure is to direct the axis of the bore on the bull's-eye of the laying target by means of cross wires at breech and muzzle, and then to adjust the deflection leaf of the sight so that the line of sight is on the same point.

(2.) The mounting should, if possible, be the Service one for the gun, and the platform should be similar to that on which the carriage will be mounted in the Service. A difficulty in meeting these conditions occurs in the case of field guns, the wheels of which must be on firm and perfectly level surfaces, while the spade (in carriages fitted with them) must at the same time be in average holding soil.

(3.) The selection of the ammunition demands great care.

The cartridges must be made up in all respects in accordance with the approved design, and the powder or cordite employed must be of one and the same Lot for all the cartridges; this Lot should be especially selected as having given a velocity in proof at as near the mean of the specification as possible. Minute care is essential that the cartridges all contain the correct weight of propellent.

Cordite cartridges for all range and accuracy practice are heated to 60° Fahr., and if the temperature of the air is much above this it may not be possible to keep that of the cordite down ; this is one of the objections to carrying out range table programmes in very hot weather, and it is a peculiarly objectionable condition where, from some unavoidable cause, the series for velocities has been carried out on a different day and at a different temperature to the remainder of the programme ; in such an instance it is most desirable that the temperatures of as many individual cartridges as posssible should be recorded during the practice, though it will probably be almost impossible to compile a satisfactory range table under such conditions, and it may be said that it is essential that the velocity series, or some of it at least, must be repeated on the day on which the range and accuracy practice is carried out ; this could generally be met by taking muzzle velocities in the series at the lowest elevation.

The projectiles and the driving bands must be of the latest approved pattern, and each individual one of the former must be brought up to the exact weight. Strictly speaking, all the projectiles used should be of the mean diameter of the manufacturing limits allowed, for those at the high limit will probably shoot more accurately than those at the low, but it is obviously impracticable to go in for such refinements ; at the same time, it is desirable to guage all the shells, to ascertain that there is nothing abnormal about any of them. All should be clean and free from grit on loading.

Time fuzes should all be from the same thousand, and from one which, at proof, gave a time of burning, when corrected for barometer, at the mean of the Specification.

Electric tubes should always be employed, to avoid any chance of disturbing the laying by the pull on the lanyard required for friction or percussion tubes.

(4.) In carrying out the programme the first essential is that there should be as little wind as possible, owing to the great difficulty in making corrections for its effect ; practice should not be carried out should the force exceed 3 (about 15 f.s.), but when the direction is nearly at right angles to the line of fire this may be exceeded, as the correction for drift can easily be calculated, and can never be actually determined by practice unless the wind be blowing directly up or down the range—conditions which are very unfavorable for obtaining data on which to base a range table ; it follows that a day should be chosen for the practice when the wind blows across the line of fire.

(5.) It is of great importance that the whole of Series I. should be carried out on the same day, and with as much expedition as possible, so as to minimise the chance of a change in the atmospheric conditions ; with this object it is desirable to employ two range parties, so as to obviate the delay caused between each series when one party has to travel a considerable distance to take up a position for observing the result of the next. With this object also it is undesirable to unduly lengthen the programme by firing at more elevations than are absolutely necessary, and this point is always borne in mind in the preparation of the programme ; thus, with a high velocity gun of large calibre, five elevations are not, as a rule, exceeded, nor any more than three, or at most four, rounds fired at each, while the maximum elevation which might be allowed by the mounting is rarely employed. With small calibres ranging a comparatively short distance, six or more elevations are frequently employed, and six rounds fired at each, if thought desirable, although so large a number in each series is not, as a rule, to be recommended. They are very often useful if the weather should be hazy and there is a possibility of the time of flight of an occasional round not being observed—the time of flight being of great importance in the case of field guns to ensure a good fuze scale.

(6.) The force of the wind is registered (as each round is fired) at the top of a tower at Shoeburyness, about 70 feet above the ground ; its direction is also recorded, and any changes carefully watched for. It is desirable that the angle which this direction makes with the line of fire should be given in degrees, and it is hoped that improved instruments will shortly be installed which will register the velocity with accuracy, for although our formulæ at present do not give very reliable results, and of course nothing can be known of the force in the upper strata of the atmosphere, it is well to have the best data available, if only for possible future investigations regarding wind correction.

(7.) The height of the barometer and the temperature of the air are important items, and should be recorded at regular intervals throughout the practice, for should one or more series have to be carried out on a subsequent day, or should the barometer and thermometer readings be abnormally high or low, it will be necessary to make corrections for them, and this data is essential in the fuze-scale series.

(8.) The height of the axis of the gun above the sands is required to be entered in the report of firing, and as the sands at

Shoeburyness are not horizontal, they have been carefully surveyed along the various lines of pegs marking the ranges, and a table exists for each of the several emplacements, showing the height of the floor above the sands at every 1,000 yards along which a gun on that emplacement can be fired; by this means the height of the axis of the gun above the point of impact of the projectile at any part of the range can be determined. Owing to possible shifting of the sands this survey requires occasional revision, its accuracy being most required at the short and medium ranges.

(9.) It is very necessary that the ramming home of the projectiles should be as uniforn as possible in all the rounds; this is a matter of drill and experience, but it is desirable, as a check, that the distance of the base of the projectile from the base of the breech should be recorded each round, as the information may prove useful subsequently, and throw light on the cause of an abnormal round, should such occur.

Too much stress cannot be laid on the necessity for recording in the report anything abnormal or peculiar in the behaviour of projectiles during flight, as noticed either at the gun or on the range, and as many projectiles as possible should be recovered, and full details furnished of anything abnormal in them or their driving bands.

Before the compiler of the range table is justified in rejecting any individual round as abnormal he must have conclusive evidence as to the cause, and unless he can be sure that this is quite exceptional the round should not be rejected. It may be remarked here that in compiling the probability tables no round should ever be rejected as abnormal, except for some cause not traceable to the fault of gun or ammunition.

METHOD OF CARRYING OUT THE PROGRAMME AND RECORDING THE RESULTS.

Series I. (a).

The first pair of velocity screens should be as near the muzzle as possible, always provided that the near screen is outside the influence of the blast of the discharge; the distance between the screens in each pair depends upon the velocity anticipated, and the maximum is usually 180 feet for high velocity guns, the distance being considerably less for low velocities.

A thin screen of cardboard or canvas is employed at 500 or 1,000 yards, for registering the strikes, for subsequent use in ascertaining the elevation for this range and for calculating the jump; the velocity screens are placed at equal distances on either side of this target.

The gun is then laid on the bull's-eye of the target, by means of cross wires at the breech and muzzle ends of the bore, and the angle of depression recorded by means of a clinometer : sufficient elevation is then given to ensure the target being struck as near the bull's-eye as possible. It will be observed that this procedure eliminates any error in clinometer plane or clinometer, and is independent of the height of axis above the sands at the target.

The 5 rounds are now fired, and the velocities between each pair of screens and the horizontal and vertical distance of the point of impact on the target from the bull's-eye are recorded, and the results worked out as in the following example.

N.B.—It is essential that the two pairs of velocity instruments are reading as nearly as possible the same, and steps have to be taken to ensure this.

Example :

Series I. (a.)

Gun - -		15-pr. Q. F.
Projectile - -		Shrapnel shell, weight 14 lbs. 6 oz.
Velocity screens -	1st pair -	1st screen, 70 feet from muzzle. 180 feet between screens.
	2nd pair -	1st screen, 470 yards from muzzle. 180 feet between screens.
Barometer - -		30·50 inches.
Thermometer -		34 degrees.

The quadrant angle of depression of the gun when laid on the target by cross wires in the bore was 24 minutes, and the gun was then elevated through an angle of 22 minutes. The results of firing (omitting Round 1) were :—

No. of Round.	Observed Velocity at 160 ft. from Muzzle.	Observed Velocity at 500 yds. from Muzzle.	Shot struck with regard to Centre of Target.
	f. s.	f. s.	Inches.
2	1585.5	1415	2.5 up
3	1590.5	1415	3.5 up
4	1570	1398	5.0 down
5	1597.7	1424	Center.
6	1594.5	1422	7.2 down
	Mean point of impact................		1.2 down

As the mean point of impact is only 1.2 inches below the center of the target the *tangent elevation* for 500 yards may be taken as 22 minutes (mean).

We now take each round separately, and determine in the following order C, the M. V. and the jump. For round 2 we have:—

$$*C = \frac{1500 - 160}{S_{1585.5} - S_{1415}}$$

from which $C = 1.722$

To find the muzzle from the observed velocity :—

$$S_V = S_{1590.5} + \frac{160}{1.722}$$

from which $V = 1607$ f. s.

To find the jump we must find the theoretical angle of departure which the projectile should have to strike the center of the target when the M. V. is 1607 f. s., and the remaining velocity at the target is 1415 f.s. To do this we first find the vertical height through which the projectile would fall during the time of flight from muzzle to target; this time of flight is—

$$1.722\,(T_{1607} - T_{1415})$$

and $\frac{1}{2}gt^2 = 16.04$ feet.

Then the theoretical angle of departure - - - - $\left.\right\} = \tan^{-1}\frac{16.04}{1500}$

$= 36\frac{3}{4}$ minutes.

Tangent elevation for this round (which struck $2\frac{1}{2}$ inches up, corresponding to $\frac{1}{2}$ minute at 500 yards $\left.\right\} = 21\frac{1}{2}$ minutes.

$\therefore$ Jump $= + 14\frac{1}{4}$ minutes.

Repeating the above method in each of the other rounds we obtain the following for the 5 rounds :—

No. of Round.	C.	Muzzle Velocity.	Jump.
		f. s.	Minutes.
2	1.7223	1607	+ 15.25
3	1.6753	1612	+ 15.75
4	1.6916	1591	+ 14
5	1.7022	1619	+ 14.50
6	1.7097	1616	+ 13
Means	1.7002	1609	$+ 14\frac{1}{2}$

---

* In this practice the wind was blowing at right angles to the line of fire; had there been a wind of, say, 20 f. s., directly against the motion of the projectile the expression for C would have been

$$\frac{1500 - 160}{S_{1585.5 + 20} - S_{1415 + 20}}$$

had the wind been blowing with the motion of the projectile, 20 would have had a negative prefix. Of course these values of V and v are only taken in computing C, and not in the subsequent calculations.

To find the coefficient of reduction from the mean value of C found above :—

$$\begin{aligned} \log C &= 0.2304 \\ \log \tau &= 0.0302 \\ \log \frac{w}{\kappa\sigma . d^2} &= 0.2606 \\ \log \frac{w}{d^2} &= 0.2033 \\ \log \kappa\sigma &= \bar{1}.9427 \\ \kappa\sigma &= 0.8764 \end{aligned}$$

RESULTS OF PRACTICE IN SERIES I. (*b*.)

Barometer.—30.50 inches.

Thermometer.—Dry bulb, 34 degrees ; wet bulb, 29 degrees.

Abstract.

Rounds.	Elevation (Quadrant).	Means.					Height of Axis of Gun above Sands.	Wind.	
		Time of Flight.	Range.	Error in Range.	Lateral Deviation.	Error in Direction.		Velocity (70 Feet above Ground.	Force and Direction.
	° ′	secs.	yards	yards	yards R.	yards	feet	f.s.	
6	2 0	4.02	1,644	32.0	4.1	1.36	15.3	16	↗ 2 to 4
6	5 0	7.98	2,955	13.5	14.8	1.7	16.9	17	
6	8 0	11.77	4,040	21.8	28.0	2.06	18.3	14	
6	12 0	16.45	5,194	10.2	56.2	5.37	19.5	13	
6	16 15	5 rounds 21.13	6,210	16.8	103.0	5.3	21.13	16	

(1). The first procedure is to carefully analyse the detailed report of the practice, of which the above is the abstract. Attention is at once focussed on the error in range at 2°, and we find the details were as follows :—

Round.	Time of Flight.	Range.
1	3.96	1,632
2	4.02	1,666
3	3.95	1,657
4	4.03	1,676
5	4.04	1,674
6	4.12	1,561

Comparing the time and range in Round 6 we have little hesitation in rejecting this round in view of the accuracy in all the other series, and having regard to the time of flight ; the mean then becomes—

Time - - -	4·00 secs.
Range - - -	1,661 yards.
Error in range -	13·2 "

(2.) Find the tangent elevation (that given in col. 2 being quadrant elevation), and then tabulate the angles of departure for purposes of subsequent calculation, bearing in mind, however, that the *former* is what we shall give in our completed range table.

In the 2° series we must add the angle due to height of axis at 1,661 yards [*see* (1)], this is—

$$\tan^{-1}\frac{15\cdot3}{1661\times3}=10\tfrac{1}{2}\text{ minutes}$$

and proceeding in a similar manner for each elevation we get—

Quadrant Elevations -	2°	5°	8°	12°	16° 15′
Corrections - - -	10½′	6½′	5′	4′	4′
Tangent Elevations -	2° 10½′	5° 6½′	8° 5′	12° 4′	16° 19′
Jump (+) - - -	14½′	14½′	14½′	14½′	14½′
Angles of Departure -	2° 25′	5° 21′	8° 19½′	12° 18½′	16° 33½′

(3.)—*Determine the Correct Coefficient of Reduction at each Elevation.*

In the 2° series, with which we commence, the value of $\kappa\sigma$ found from the remaining velocities would naturally be first tried, and as the atmospheric conditions are the same as in that practice, and the correction for height of trajectory may be neglected, the mean value of C previously found may be taken; then working by the formulas for direct fire and making use of Hadcock's Table VI.

$$\log C = 0\cdot2304$$
$$\log\sin 4^\circ\ 50 = \bar{2}\cdot2256$$
$$\log a = 2\cdot6952$$
$$a = 0\cdot04957$$

and consulting Table VI. (Hadcock's pamphlet of 1897) for $V = 1609$,

$$\text{reduced range} = 984\cdot4 \text{ yards}$$
$$\log\ \text{"}\quad\text{"} = 2\cdot9932$$
$$\log C = 0\cdot2304$$
$$\log R = 3\cdot2236$$
$$R = 1673 \text{ yards}$$

which is only 12 yards more than that found in practice, or that $\kappa\sigma = \cdot8764$, the value found on page 165, from the remaining velocities is confirmed at this elevation.

It will be found very useful to tabulate the *Tangent* elevations for every 100 yards at this stage, as it enables us to determine the approximate angle of descent in the following calculations, and thereby save labor. Taking the ranges as abscissæ and the tangent elevations in para. (2) as ordinates, we plot a curve, bearing in mind that the origin will not be at zero, but a point corresponding to 14½ minutes *below* the zero point, on account of the jump being positive (had the jump been negative the origin would be at 14½ minutes *above* the zero point); it is also to be remembered that we have a very important point on the curve at the 500 yards range, where the ordinate is 22 minutes, as found in the calculations on Series I. (*a*).

We have thus seven points on the curve, including the origin (which is given us by the jump), and if the practice has been good and the data is reliable no point should be off the curve when a flexible ruler is applied to them, in fact, in a good example like the present one, the prolongation of the curve below the 500 yards point may almost be relied upon to find the jump without any calculation; in this case it confirms the calculations.

It will generally be found desirable, especially with high velocity guns, and in cases where the interval between the target and the next range is great, to calculate an intermediate point on the curve, for any slight sagging of the flexible ruler at this point when striking the curve may easily make a couple of minutes error in the elevation, which here means an appreciable error in the range.

In this particular case it is scarcely necessary, but, if desired, 1,000 yards would be taken, and, with the same value of C, work in the converse manner to that in the beginning of this paragraph, thus:—

$$\begin{aligned} \log 1{,}000 &= 3\cdot 0000 \\ \log C &= 0\cdot 2304 \\ \log (\text{reduced range}) &= 2\cdot 7696 \\ \text{reduced range} &= 588 \text{ yards.} \end{aligned}$$

Then, using Hadcock's Table VI., and finding *d* for V = 1,609, and using the formula—

$$\text{Sin } 2\phi = a\,C,$$

we easily find $\phi = 1^\circ\ 17$

and the tangent elevation $= 1^\circ\ 2\tfrac{1}{2}'$.

Now, taking the next series with angle of departure of 5° 21′, and trying the same value of $\kappa\sigma$ as in the last series, but taking altitude into account, it is found that, using Hadcock's Table VI., the range works out to 2,985 yards,* and with the longer method by the direct fire formulas, and taking in η and the pseudo velocities in the descending branch, it works out to 2,958 yards, and as this is practically correct, we may here record the values of v and β found incidentally,

---

* Working with the *horizontal* muzzle velocity, the range works out to 2,968 yards.

$\kappa\sigma = 0{\cdot}8764$
R = 2958 yds.
$v = 911$ f. s.
$\beta = 7^\circ\ 40'$
$y_0 = 253{\cdot}7$
T = 7·85 secs.

In the 8° series it will be safe to assume that some reduction in the value of $\kappa\sigma$ may be ventured upon, and 0·855 may be tried in the first instance.

It is desirable in this and subsequent series to employ the modified formulas for curved fire, making, of course, the necessary correction in C for the altitude; the steps need not be gone into, as a complete example will be given for the 16° series.

The following values are found, the value of R proving to be sufficiently near the observed range to be accepted.

$\kappa\sigma = 0.855$
R = 4027 yds.
$v = 826$ f. s.
$\beta = 12^\circ\ 25'$
$y_0 = 557{\cdot}4$ ft.
T = 11·56 secs.

In the 12° series the result of calculation are—

$x\sigma = {\cdot}83$
R = 5,185 yds.
$v = 764$ f. s.
$\beta = 18^\circ\ 42'$
T = 16·06 secs.
$y_0 = 1{,}090$ ft.

The complete calculation for the maximum elevation is given as follows:—

A preliminary calculation with a value of $\kappa\sigma$ of ·82 having shown this to give rather too great a range, the same value is taken as in the 12° series, viz., ·83.* U = 1564·3 is obtained in the usual way, $\phi' = 16^\circ\ 33\tfrac{1}{2}'$, $\eta = 9^\circ\ 29'$, $T = 21\cdot13$ secs. (from the practice).

---

* This agrees closely with the result obtained by employing Siacci's table of function $\bar{\beta}$; thus, taking the original value of $\kappa\sigma$ found from the remaining velocities, and $\bar{\beta} = {\cdot}95$ from the table,—

$\log {\cdot}8764 = \bar{1}{\cdot}9427$
$\log {\cdot}95 = \bar{1}{\cdot}9777$
$\log .8325 = \bar{1}{\cdot}9204$

$$\begin{aligned}
\log \frac{w}{\tau \cdot d^2} &= \cdot1731 \\
\log \cdot83 &= \bar{1}\cdot9191 \\
&\ \cdot2540 \\
\log f &= \cdot0186 \\
\log C &= \cdot2726 \\
\log \sec \eta &= \cdot0062 \\
\log C \sec \eta &= \cdot2788 \\
\log \tan 16^\circ\ 33\tfrac{1}{2}' &= \bar{1}\cdot4732 \\
&\ \bar{1}\cdot1944 \\
&\ \cdot15647 \\
I(U) &= \cdot866658 \\
I(u_0) = I(U) - \frac{\tan \phi'}{C \sec \eta} &= \cdot710188 \\
\therefore\ u_0 &= 867\cdot5 \text{ f. s.}
\end{aligned}$$

$$\begin{aligned}
\log T &= 1\cdot3249 \\
\log T^2 &= 2\cdot6498 \\
\log 4 &= \cdot6021 \\
\log y_0 &= 3\cdot2519 \\
\text{constant } \log &= 5\cdot0176 \\
\log (\log f) &= \bar{2}\cdot2695 \\
\log f &= \cdot0186
\end{aligned}$$

Then using the formula

$$\frac{y_0}{x_0} = \tan \phi' - C \sec \eta \left\{ I(U) - \frac{A(U) - A(u_0)}{S(U) - S(u_0)} \right\}$$

$$\begin{aligned}
A(U) &= 8334\cdot4 \\
A(u_0) &= 3808\cdot3 \\
A(U) - A(u_0) &= 4526\cdot1 \\
S(U) &= 43449\cdot9 \\
S(u_0) &= 37806\cdot5 \\
S(U)\ S(u_0) &= 5643\cdot4 \\
\log \{A(U) - A(u_0)\} &= 3\cdot6556 \\
\log \{S(U) - S(u_0)\} &= 3\cdot7515 \\
\log \frac{A(U) - A(u_0)}{S(U) - (Su_0)} &= \bar{1}\cdot9041 \\
\frac{A(U) - (Au_0)}{S(U) - (Su_0)} &= \cdot801900 \\
I(U) &= \cdot766658 \\
I(U) - \frac{A(U) - A(u_0)}{S(U) - S(u_0)} &= \cdot064758 \\
\log \{\quad ``\quad\} &= \bar{2}\cdot8113 \\
\log C \sec \eta &= \cdot2788 \\
&\ \bar{1}\cdot0901 \\
C \sec \eta \left\{ I(U) - \frac{A(U) - A(u^0)}{S(U) - S(u_0)} \right\} &= \cdot1230 \\
\tan \phi' &= \cdot29731
\end{aligned}$$

$$\begin{aligned}
\log S(U) - S(u_0) &= 3\cdot7515 \\
\log C &= \cdot2726 \\
\log \cos \eta &= \bar{1}\cdot9938 \\
\log x_0 &= 4\cdot0179 \\
x_0 &= 10421 \text{ ft.}
\end{aligned}$$

$$\begin{array}{rl} \frac{y_0}{x_0} = & \cdot 17431 \\ \log \frac{y_0}{x_0} = & \bar{1}\cdot 2412 \\ \log x_0 = & 4\cdot 0179 \\ \hline \log y_0 = & 3\cdot 2591 \\ y_0 = & 1816 \text{ feet.} \end{array}$$

To verify the correction that was made for altitude

$$\begin{array}{rl} \log y_0 = & 3\cdot 2591 \\ \text{constant } \log = & \bar{5}\cdot 0176 \\ \hline \log (\log f) = & \bar{1}\cdot 2767 \\ \log f = & \cdot 0189 \end{array}$$

The method by the time of flight gave ·0186, which was, therefore, quite close enough.

It has already been recommended that the elevation should be tabulated for every 100 yards in range; from this we take the elevation for 6,110 yards and 6,310 yards, and $\Delta\phi$ for 200 yards is found to be 54 minutes; we can approximate to the angle of descent for a range of 6,210 by the formula

$$\tan \beta = \frac{6110 \times \sin 54'}{200}$$

from which $\beta = 25^\circ\ 38'$.

Try $\beta = 25^\circ\ 45'$ for the descending branch; then $\eta' = 15^\circ\ 25'$ and since

$$U_0 = v_0 \sec \eta \cos \eta$$

we get

$$\begin{array}{rl} U_0 = & 887.5 \text{ f. s.} \\ \log C = & \cdot 2726 \\ \log \sec \eta' = & \cdot 0160 \\ \hline \log C \sec \eta' = & \cdot 2886 \\ \log \tan 25^\circ\ 45' = & \bar{1}\cdot 6833 \\ \hline & \bar{1}\cdot 3947 \\ & \cdot 2481 \\ I(U_0) = & \cdot 72469 \\ \hline I(v) = & \cdot 47659 \\ v = & 673 \text{ f. s.} \end{array}$$

For the descending brance the formula is

$$\frac{y'_0}{x'_0} = C \sec \eta' \left\{ I(U_0) - \frac{A(U_0) - A(v)}{S(U_0 - S(v)} \right\}$$

$$
\begin{aligned}
A(U_0) &= 4056{\cdot}8 \\
A(v) &= 1285{\cdot}3 \\
\hline
A(U_0) - A(v) &= 2771{\cdot}5 \\
S(U_0) &= 38152{\cdot}9 \\
S(v) &= 33619.8 \\
\hline
S(U_0) - S(v) &= 4533{\cdot}1 \\
\log\{A(U_0) - A(v)\} &= 3{\cdot}4427 \\
\log\{S(U) - S(v)\} &= 3{\cdot}6564 \\
\hline
& \quad \bar{1}{\cdot}7863 \\
\frac{A(U_0) - A(v)}{S(U_0) - S(v)} &= {\cdot}6114 \\
I(U_0) &= {\cdot}72469 \\
I(U_0) - \frac{A(U_0) - A(v)}{S(U_0) - S(v)} &= .11329
\end{aligned}
$$

$$
\begin{aligned}
\log\{S(U_0) - S(v)\} &= 3{\cdot}6564 \\
\log C &= {\cdot}2726 \\
\log \cos \eta' &= \bar{1}{\cdot}9840 \\
\hline
\log x'_0 &= 3{\cdot}9130 \\
x'_0 &= 8183 \text{ ft.}
\end{aligned}
$$

$$
\begin{aligned}
\log\{ \quad `` \quad\quad `` \quad \} &= \bar{1}{\cdot}3432 \\
\log C \sec \eta' &= .2886 \\
\log \frac{y'_0}{x'_0} &= \bar{1}{\cdot}3432 \\
\log x'_0 &= 3{\cdot}9130 \\
\hline
\log y'_0 &= 3{\cdot}2562 \\
y'_0 &= 1804 \text{ feet}
\end{aligned}
$$

This is less than the height previously found by 12 feet, and 12 cot 25° 45′ feet has to be added to the range, which becomes

$$
\begin{aligned}
10421 + 8183 + 23 &= 18627 \text{ feet} \\
&= 6209 \text{ yards.}
\end{aligned}
$$

The range found in practice being 6210 yards.

The actual remaining velocity, $v = v \cos \eta' \sec \beta$

$$= 720 \text{ f. s.}$$

$$
\begin{aligned}
\text{Time of flight} &= C\{T_{1564{\cdot}3} - T_{867{\cdot}5} + T_{887{\cdot}5} - T_{673}\} \\
&= 20{\cdot}74 \text{ seconds.}
\end{aligned}
$$

That observed was 21·13 seconds.

So far, we have not determined the angles of descent and remaining velocities for the series below 5°, and these must be worked out before anything further can be done. As will be subsequently explained, the *calculated* times of flight will also be required. The formulas for direct fire are employed, and the results are as follows for 500 yards, 1,000 yards, and in the 2° series completing the table from the results already given for the other series:—

Tangent Elevation.	Angle of Departure.	Range.	Calculated.		
			Time of Flight.	Angle of Descent.	Remaining Velocity. (v.)
° ′	° ′	Yards.	Seconds.	° ′	f. s.
0 22	0 36½	500	0.993	0 37	1,415 (observed)
1 2½	1 17	1,000	2.129	1 30	1,247
		calculated			
2 10½	2 25	1,673	3.883	3 11	1,076
5 6½	5 21	2,958	7.850	7 40	911
8 5	8 19½	4,027	11.560	12 25	826
12 4	12 18½	5,185	16.060	18 42	764
16 19	16 33½	6,209	20.740	25 45	720

As a check on the calculations, it is desirable to plot each of the last three columns on a curve, taking the ranges in column 3 as the abscissæ; if any point is much off the curve the calculation for that range must be scrutinised, and an error may be detected.

CORRECTIONS FOR ATMOSPHERIC CONDITIONS WHEN THESE VARY FROM THE NORMAL.

It will have been observed that the practice was carried out under very unvavorable conditions as regards height of barometer and thermometer, the former being ½-inch above the normal, and the latter 28 degrees below it, both tending to increase the density of the air. From the table for τ we find that for barometer 30·50 inches and thermometer 34°

$$\tau = 1{\cdot}072,$$

and we must repeat the whole of our calculations with τ eliminated from C in order to find the *difference* in R, T, v and β. V cannot be altered, as we do not know what the observed velocity would have been under normal conditions.

This is extremely laborious, but the work must be faced if the range table is to be a good one. It is, however, an argument against insisting on programmes of firing being carried out without waiting for a day when suitable atmospheric conditions obtain, for what is gained in point of time by carrying it out earlier under unsatisfactory conditions is lost in the time occupied in making calculations to ascertain the necessary corrections. There is also every possibility of the unfortunate compiler of the range table losing himself in a maze of corrections and making some mistake, and in any case the result can never be so satisfactory as when the range table is based directly on the results of practice, without having to make any corrections.

Ingalls' tables are very useful in finding *differences* due to alterations in atmospheric conditions. Unfortunately in this case the tables are not sufficiently extended to take in the 16° series, and we have to repeat the calculations already given, but using C × 1·072 instead of the value employed before; the results are as follows:—

——	R.	T.	β		v
	Yards.	Seconds.	°	'	f. s.
Previous calculation with log C = .2726	6,209	20.74	25	45	720
Present calculation with log C = .3028	6.402	21.10	25	48	736
Differences due to 0.50-inch in barometer and 28° in temparature - -	193	0.36		3	16
Results of practice with barometer 30·50 inches and thermometer 34° -	6,210	21.13	——		——
Data for compilation of Range Table for barometer 30 in. and thermometer 62°	6,403	21.49	25	48	736

The corrections for each of the other series are worked out and applied in a similar manner.

Correction for Wind.—In the example under consideration the wind is blowing acros the line of fire, and may therefore be neglected; if it blows up or down the range its effect may have to be taken into account, and the only method at our disposal for determining the correction is Colonel Maitland's (*vide* Proceedings R. A. Institution, Vol. VIII., p. 343).

The steps are in the following example:—

Suppose in the practice we have already been dealing with, there was a wind of 30 f. s. blowing directly down the range, *i. e.*, with the projectile, find the correction in the 5° series.

(*a.*) Working with the direct fire formulas and the *horizontal* muzzle velocity (1,602 f. s.), find the (horizontal) remaining velocity and time of flight for the actual range obtained in practice, using the value of C found to be correct in the previous calculations, which, of course, embodied the proper correction for log *f*. These are 904 f. s. and 7·820 seconds.

(*b.*) With this time of flight, and supposing the M. V. to be the real M. V. — velocity of the wind (1,602 — 30 = 1,572), employ the T table and find the remaining velocity: this is 899·5 f. s.

(*c.*) Employ the values of muzzle and remaining velocities in (*b*) to find the range from the S table: this is 2,925 yards, which is the range *in the wind.* To find the actual range—

(*d.*) Find the distance traversed by the wind in the time found in (*a*), and add it to the range found in (*c*)—

$$\frac{7\cdot829 \times 30}{3} + 2{,}925 = 3{,}003 \text{ yards.}$$

The required correction is therefore 3,003 — 2,955 = 48 yards, which must be *deducted* from 2,955, which was assumed to have been the range obtained in practice *when the wind was blowing.*

With regard to the above method of correcting for the effect of wind, it appears from those data, which seem to be most reliable, that it does not give a large enough correction; it is probable that the force of the wind is always very much greater in the upper strata of the atmosphere than anywhere near the ground, and though it is now measured at Shoeburyness at an altitude of 70 feet above the ground, the estimate at this height is probably still considerably below what the projectile will encounter at greater heights.

At high angles of elevation the projectile presents a larger surface to the action of the wind (and this is more pronounced in the descending branch of the trajectory) than at low angles; in the former case, when the projectile reaches the horizontal position, *i. e.*, at the top of its trajectory, the wind is probably, as we have said above, blowing with greater force, and at the commencement and end of the trajectory the wind should have greater effect, owing to the inclined position of the projectile.

From the above considerations we probably much under-estimate the effect of the wind at long ranges; unfortunately, we have no other method of correcting, so we must make the best of the one given, and it is obviously unecessary to go into refinements, such as taking the resolved component of the wind in direction of the line of fire, unless, indeed, the angle is considerable and the force considerably more than is usually to be met with in range table practice.

TABULATION OF RESULTS OF PRACTICE AND CALCULATION TO FORM THE RANGE TABLE.

We are now in a position to proceed with the above, but a word may first be said on the subject of plotting curves.

There is some little difficulty in obtaining thoroughly good flexible splines with which to strike a good curve; they require to be the very best, and even then it will be found that after some use, and epecially if much employed to trace sharp curves, they are apt to assume a permanent set, when they must be discarded; it is advisable, therefore, to use the largest sheets of paper that can be obtained, and to arrange the scale of the ordinates so as to avoid short and sharp curves.

On the other hand, if too large a scale be worked to, distance between points on a curve may easily be too great, allowing of errors due to irregularity in the spline; the most critical part of the curve in the case of heavy guns of high velocity is that between the 1,000 yards target and the range for the first elevation—a distance in range of perhaps 3,000 yards. The curve here is very flat, and any slight error in the position of the spline makes an appreciable error in the results, and this is a very important part of the range table for a gun for Naval Service; it is for this reason that one or two points are generally obtained here by calculation.

(a.) Range and Elevation Columns.

These have already been tabulated from the *tangent* elevation and the actual ranges obtained in practise (*see* page 168 for particulars as to the procedure.)

In this case and in all the following it will generally be found, on comparing the "differences" for each elevation, that there are little irregularities due to the impossibility of reading to very small increments on the squared paper. It is necessary, therefore, to "smooth" the curve; that is, to jot down in pencil, between each two elevations, the difference between them, and then correct these differences so as to make them all increase regularly. Care must be taken, of course, that if any "difference" is increased there must be an equal decrease made in a neighbouring one, so as not to alter the mean run of the curve.

(b.) Alteration in Range due to 5 minutes alteration in Elevation.

The method of preparing this column is obvious; the alteration in range is calculated for various points—say, every 500 yards—and the intermediate ones interloped by means of a curve.

(c.) Five minutes in Elevation or Deflection alters the point of Impact vertically or latterally.

The correction, in either case, is

$$R \times \tan 5'.$$

Calculate this for every 500 yards or so (a slide rule is very useful for the purpose), plot the results on a curve for each of the ranges dealt with, and read off the results for all intermediate points.

(*d.*) *Remaining Velocities.*

These are the actual, that is, the striking velocities, which have been already calculated, and which were given in a previous table. Here we take the *calculated* range as the abscissa, and the corresponding remaining velocity as the ordinate ; the latter for range *nil* will, of course, be the muzzle velocity. The calculations will never give such exact results that all the points will come absolutly on a curve, and it will be necessary to alter points here and there until they do. In the case under consideration all seven points come on a curve if 911 be altered to 906, or it may be preferred to make a smaller alteration at this point and increase each of the three subsequent velocities by 2, 3, and 5 f.s. respectively ; the former alternative is preferred, however.

Having determined the curve, take off the velocity for every 100 yards, and insert in the range table.

A criticism which is frequently made on range tables is, that either the remaining velocities or the times of flight given must be incorrect, because the remaining velocities worked out from the T table do not agree with those worked from the S table. The explanation of this is given in (*f*) (time of flight).

The rough method sometimes given for checking the remaining velocity. viz., to divide the range (in feet) by the time of flight for that range, the result being the remaining velocity at half that range, is therefore very incorrect and misleading.

(*e*). *Angle of Decent.*

A good check on the angle of descent and a useful method of approximating to it for use in calculations of trajectories in two arcs is afforded by the following method :—

Example.—Find the angle of descent for our previously calculated range of 5,185 yards.

Take 100 yards on each side of this range and consult the range and elevation columns for the elevations for 5,085 yards and 5,285 yards, and it will be found that

$$\Delta\phi \text{ for 200 yards} = 46 \text{ minutes}$$

Then $$\tan \beta = \frac{5085 \sin 46'}{200}$$

where β is the angle of descent for the intermediate range between the two considered, viz., 5,185 yards.

$$\beta = 18^\circ\ 47'$$

which is very close to our previously calculated angle, which was 18° 42'.

Where $\Delta\psi$ for 200 yards is large, the above has been found to give better results than the old formula

$$\beta = \frac{\text{R} \tan \Delta\psi}{\Delta \text{R}}$$

where R was the the range *under consideration*, and $\Delta\psi$ a small angle of, say, 2 minutes; in this case taking $\text{R} = 5185$, and $\Delta\psi = 5$ minutes

$$\Delta \text{R} = \frac{500}{23} = 21{\cdot}74$$

$$\text{and } \beta = 19^\circ\ 8'.$$

Neither formula is more than a rough approximation, however, and it is a matter of taste which should be used ; the former is the simpler, and $\Delta\psi$ can be taken from the range table at a glance.

(*f*). *Time of Flight.*

The curve for these must be taken from the *actual* ranges and times of flight observed in practice, and the various points are marked on the paper. Before actually drawing the curve, however, a second curve is plotted with the *calculated* ranges and times, and it will generally be found that the latter are less than the observed times. This curve should be inked in.

If now we proceed to apply the spline to the points for the actual times, it will be found that from 0 to the 1,661 yards point the spline runs much too straight compared to the calculated curve, and beyond the 1,661 yards point it takes a set which brings it some distance below the 2,955 yards point. But if we make the spline take a curvature between 0 and 1,661 yards, as nearly *similar* to the calculated curve as we can do by eye, its curvature beyond that point alters in such a way as to embrace the 2,955 yards point, and both curves are nearly similar though slightly divergent.

It was to obtain this result that the times were calculated for the intermediate points at 500 yards and 1,000 yards as well as the other points, and without this calculated curve as a guide our spline would have led us to alter one of the observed times in order to get all points on a curve, and the times of flight between 0 and 2,955 yards would have been too great, the maximum error being probably something like 0·15 second. This would possibly have been no very serious thing in the fuze scale at such short ranges, but a critic would have been sorely perplexed at the want of agreement between practice and theory ; many of the existing range tables show this defect.

With regard to the question of the calculated times being generally *less* than the actual, Mr. Bashforth, in his pamphlet of 1900, maintains that his times of flight agree with practice ; but he takes an arbitrary coefficient of reduction with which his ranges are only equal to those obtained in practice through employing *greater elevations* in the calculations than were found in practice to give those ranges. His example therefore entirely bears out the writer's statement in this paper, that for any angle of departure for which the calculated range is equal to the range obtained in practice, the calculated time of flight will generally be found less than the observed time.

Why this should be so is a matter for consideration.

The writer cannot ascribe it to the observed times being too long, because the error is far too great to be accounted for by faulty observation ; the clocks used at Shoeburyness are the best that can be obtained for money, and are frequently sent to the makers for overhaul, and occasionally to Kew for testing ; any delay due to personal error should be about equal at starting and stopping, and thus be eliminated ; several observers take times independently and the results are collated, compared with the ranges, and any said to be doubtful (the observer himself is always conscious of whether his observation was good or bad) are set aside ; from constant practice the observers become so expert that their results agree with remarkable exactness.

In view of the methods employed in the original experiments of Mr. Bashforth, on which the ballistic tables were based, there is much to be said in favor of working from the *time and range* rather than from the *elevation and range*, as has been done in this paper ; it would, however, be impracticable to work from the former in the calculations required in the compilation of range tables.

(g). *Fuze Scale.*

This is obtained from the results of firing in Series 11. of the Programme, which we have not yet given ; they were as follows:—

Setting of Fuzes.	Mean Time of Burning.	
	As observed (Barometer 30.50 inches.)	Correctrd for Barometer 30.00 inches
	Seconds.	Seconds.
5	4.37	4.42
9	8.35	8.45
14	14.66	18.84
18	19.57	19.81

The rule for obtaining the corrected time of burning is that 1 inch of diminution in height of barometer increases the time of burning by 0·03 of the total time for any particular setting, and *vice versa* for an increase in height of barometer.

Column (3) above is therefore obtained from column (2) by multiplying the figures in the latter by 1·015 to obtain the correction for ½ inch.

The procedure is now as follows :—

> Plot a curve of settings and times from the data in columns (1) and (3) in the above table ; consult the time and range curve [already plotted in (*f*) from the actual practice], and note the times for every 100 yards from this curve ; then, from the time and settings curve, the setting for every 100 yards in range can be read off (in units, halves, and quarters).

(*h.*) *Probability Columns.*

Taking the length column first, multiply the mean error in range in each series by 1·69, and the result is the length of the probable rectangle for that series ; these are all plotted as ordinates with the range corresponding as the abscissa. The starting point of the curve will not be at zero, but at the 500 yards target ; in this we have only the mean vertical error, which is 2·92 inches, and as the angle of descent at 500 yards was found by calculation to be 37 minutes, the mean error in range is—

$$\frac{2{\cdot}92 \times \cot 37'}{36} = 7{\cdot}53 \text{ yards.}$$

This, multiplied by 1·69, gives the first point for the curve. The mean error at the next point, it will be remembered, was 13·2 yards at 1,661 yards range, and not that given in the abstract of practice, because we cast out one obviously wrong round. Except in a case of obvious mistake, as in this case, *apparently* abnormal rounds are never cast out, but at the same time all the points for the curve will never be found to come on to a regular curve which has to be run, as nearly as can be judged, so as to keep as near the various points as possible, some being above and some below.

The same procedure is followed for the breadth zone.

The height zone is derived from the length zones already tabulated above, and from the angle of descent column, the height being equal to the length × tangent of angle of descent for the particular range under consideration. These are worked out for every 500 yards or more, plotted on a curve, and the intermediate points taken from it for every 100 yards.

(*i.*) *Height of Vertex of Trajectory.*

(*j.*) *Horizontal Range to Vertex.*

Both of these are to be given in the future range tables for Naval Service; these are found in the usual course of the calculations, and are tabulated in the ordinary way for every 100 yards in range.

(*k.*) *Penetration into Wrought Iron.*

This is for armour-piercing shot, and is therefore only required in range tables for guns provided with such projectiles. The penetration is calculated by the usual formulas for various ranges for the striking velocity at those ranges as tabulated in (*d*), bearing in mind that the angle of incidence (in this case the angle of descent) must be taken into account.

A note is sometimes added to the range table giving the comparative *resistance* to *perforation* of various types of plate, viz. :—

Wrought iron	1
Compound, or mild steel	$1\frac{1}{8}$
Harveyed, or Krupp non-cemented	2
Krupp-cemented	$2\frac{1}{8}$

This, however, is a very rough estimate.

Correction for Drift.

Colonel Ingalls, U. S. Artillery, gives a useful and simple method of finding the drift (Ballistic Tables, 30th April 1900).

For heavy guns,

$$\text{Drift (in yards)} = \frac{C^2 D^1}{\cos^3 \phi} \log^{-1} (3{\cdot}7924)$$

and for field guns,

$$\text{Drift (in yards)} = \frac{C^2 D^1}{\text{Cos}^3 \phi} \log^{-1} (3{\cdot}9243)$$

D^1 being obtained from one of the columns given in his tables, to which the reader is referred.

The results obtained by the use of the above formulas agree very closely with those observed in practice with our projectiles.

The drift is corrected for, in guns, by inserting the sight at a permanent angle of inclination to the left; this angle for any particular range is found from the following formula,

$$\tan \theta = \frac{d}{R} \operatorname{cosec} \alpha$$

in which, θ = angle of inclination of sight
d = drift in yards at range R.
R = Range
α = tangent elevation for range R.

θ will vary for every range, consequently d must be calculated by Ingalls' formula for several ranges, and θ calculated for each of these ranges with the known values for d, R, and a.

Taking the practice with which we have been dealing in the foregoing pages, the results work out as given in the following table, in which the actual deviation is given for comparison, as it is interesting as showing the effect of the wind, which was blowing from left to right with a velocity of 13 to 17 f.s. ; the difierence between the actual and calculated deviation is therefore due to the wind.

Range from Practice.	Lateral Deviation in actual Practice.	Calculated	
		Deviation due to Dritt.	Angle of Inclination of Sight to correct for Drift.
Yards.	Yards.	Yards.	° ′
1,661	4.1	2.17	1 59
2,955	14.8	9.64	2 6
4,040	28.0	22.80	2 18
5,194	56.2	46.90	2 29
6,210	103.0	82.03	2 42

The method usually adopted has been to take the mean of the angles in the last column for the angle of inclination of the sight; the error in the correction given at each range is shown in the table below, and that for two other angles of inclination is also given for comparison. As might be expected, none of them give entirely satisfactory results, but in the last column is shown the effect of inclining the sight at the maximum angle and adding a further correction by giving 3 minutes permanent *deflection-right* in the adjustment of the deflection scale.

The result is decidedly satisfactory, but, whatever method is adopted, the principle to be borne in mind is that, for naval range tables, the short ranges, up to about 2,000. yards, are the most important, while for field guns, for example, from 3,000 to 5,000 would probably be allowed to be best. In fact, the average fighting range must be legislated for.

Range.	Error in the Correction when Sight is inclined at 2° 18′ (Mean Angle.)	2° 29′	2° 42′	Error in Correction with Sight inclined at 2° 42′ and 3 minutes. Permanent *Right* Deflection.
Yards.	Feet.	Feet.	Feet.	Feet.
1,661	+ 1.0	+ 1.5	+ 2.3	— 1.7
2,955	+ 2.3	+ 5.2	+ 8.0	+ 0.7
4,040	*Nil*	+ 5.4	+ 11.7	+ 1.6
5,194	—10.3	*Nil*	+ 12.3	— 0.7
6,210	—36.9	—19.6	*Nil*	— 15.5

H. P. HICKMAN, Major, R. A.

28th March 1901.

See Note by Lieutenant Colonel Jas. M. Ingalls, U. S. Army, Retired, page 187.

TABLE I.

SIACCI'S TABLE OF FUNCTION β.

TABLE

Siacci's Table

(*From Journal of the United*

φ Degs.	RANGE									
	1,100	2,200	3,300	4,400	5,500	6,500	7,600	8,700	9,800	10,900
6	1.00	0.99	1.00	1.00	1.00	—	—	—	—	—
7	1.00	0.99	0.99	1.00	1.00	—	—	—	—	—
8	1.00	0.99	0.99	0.99	1.00	—	—	—	—	—
9	1.00	0.99	0.99	0.98	0.99	—	—	—	—	—
10	1.00	1.00	0.98	0.98	0.99	—	—	—	—	—
11	1.01	1.00	0.98	0.97	0.98	1.00	1.00	1.00	—	—
12	1.01	1.00	0.98	0.96	0.97	1.00	1.00	1.00	—	—
13	1.01	1.00	0.98	0.97	0.96	0.99	1.00	1.00	—	—
14	1.01	1.00	0.99	0.97	0.95	0.98	0.99	1.00	—	—
15	1.01	1.00	0.99	0.98	0.96	0.96	0.98	0.99	—	—
16	1.02	1.01	1.00	0.99	0.95	0.95	0.97	0.99	—	—
17	1.02	1.01	1.00	0.99	0.96	0.94	0.96	0.98	—	—
18	1.02	1.01	1.00	1.00	0.96	0.92	0.95	0.97	0.99	1.00
19	1.02	1.01	1.00	1.00	0.97	0.94	0.92	0.94	0.97	1.00
20	1.03	1.02	1.01	1.01	0.98	0.94	0.91	0.92	0.96	0.99
21	1.03	1.03	1.02	1.01	0.99	0.95	0.90	0.91	0.95	0.98
22	1.03	1.03	1.02	1.02	1.00	0.96	0.89	0.89	0.93	0.97
23	1.03	1.03	1.02	1.02	1.01	0.97	0.88	0.88	0.92	0.96
24	1.04	1.04	1.03	1.03	1.02	0.98	0.88	0.87	0.91	0.95
25	1.04	1.04	1.03	1.03	1.02	0.99	0.89	0.86	0.89	0.93
26	1.05	1.05	1.04	1.04	1.03	1.00	0.90	0.85	0.88	0.91
27	1.05	1.05	1.04	1.04	1.04	1.01	0.91	0.85	0.86	0.89
28	1.05	1.05	1.05	1.05	1.04	1.02	0.93	0.86	0.84	0.87
29	1.06	1.06	1.06	1.05	1.05	1.03	0.95	0.87	0.82	0.85
30	1.06	1.06	1.06	1.06	1.05	1.04	0.97	0.88	0.81	0.83
31	1.07	1.07	1.07	1.06	1.06	1.04	0.98	0.89	0.81	0.82
32	1.07	1.07	1.07	1.06	1.06	1.05	1.00	0.90	0.82	0.81
33	1.08	1.08	1.08	1.07	1.07	1.05	1.01	0.92	0.82	0.81
34	1.09	1.09	1.08	1.07	1.07	1.06	1.02	0.94	0.83	0.80
35	1.09	1.09	1.08	1.08	1.08	1.06	1.03	0.96	0.84	0.80
36	1.10	1.10	1.09	1.08	1.08	1.07	1.04	0.98	0.84	0.79
37	1.11	1.10	1.09	1.08	1.07	1.07	1.05	0.99	0.85	0.79
38	1.11	1.10	1.09	1.09	1.08	1.08	1.06	1.00	0.87	0.80
39	1.12	1.11	1.10	1.09	1.09	1.09	1.07	1.01	0.89	0.80
40	1.13	1.12	1.12	1.11	1.11	1.10	1.08	1.02	0.90	0.81
41	1.14	1.13	1.12	1.12	1.11	1.11	1.09	1.03	0.91	0.81
42	1.15	1.14	1.13	1.13	1.12	1.12	1.10	1.04	0.92	0.81
43	1.16	1.15	1.14	1.14	1.13	1.13	1.11	1.05	0.92	0.82
44	1.17	1.16	1.15	1.15	1.14	1.14	1.11	1.06	0.93	0.82
45	1.18	1.18	1.17	1.17	1.16	1.15	1.11	1.07	0.94	0.83

I.

OF FUNCTION $\bar{\beta}$.

States Artillery, January, 1900.)

(Yards).										ϕ Degs.
12,000	13,100	14,200	15,300	16,400	17,500	18,600	19,700	20,800	21,900	
—	—	—	—	—	—	—	—	—	—	6
—	—	—	—	—	—	—	—	—	—	7
—	—	—	—	—	—	—	—	—	—	8
—	—	—	—	—	—	—	—	—	—	9
—	—	—	—	—	—	—	—	—	—	10
—	—	—	—	—	—	—	—	—	—	11
—	—	—	—	—	—	—	—	—	—	12
—	—	—	—	—	—	—	—	—	—	13
—	—	—	—	—	—	—	—	—	—	14
—	—	—	—	—	—	—	-	—	—	15
—	—	—	—	—	—	—	—	—	—	16
—	—	—	—	—	—	—	—	—	—	17
1.00	1.01	—	—	—	—	—	—	—	—	18
1.00	1.00	—	—	—	—	—	—	—	—	19
0.99	1.00	—	—	—	—	—	—	—	—	20
0.99	1.00	—	—	—	—	—	—	—	—	21
0.98	0.99	—	—	—	—	—	—	—	—	22
0.98	0.99	—	—	—	—	—	—	—	—	23
0.97	0.99	1.00	1.00	1.01	1.01	1.02	—	—	—	24
0.95	0.98	0.99	1.00	1.01	1.01	1.02	—	—	—	25
0.93	0.96	0.99	1.00	1.01	1.01	1.02	—	—	—	26
0.92	0.95	0.98	0.99	1.00	1.01	1.01	—	—	—	27
0.91	0.94	0.97	0.98	1.00	1.01	1.01	—	—	—	28
0.89	0.93	0.96	0.97	0.99	1.00	1.01	—	—	—	29
0.88	0.92	0.95	0.97	0.99	1.00	1.01	—	—	—	30
0.86	0.90	0.93	0.96	0.98	1.00	1.01	—	—	—	31
0.85	0.88	0.91	0.94	0.97	0.99	1.00	—	—	—	32
0.83	0.86	0.90	0.93	0.96	0.98	1.00	—	—	—	33
0.81	0.84	0.88	0.92	0.95	0.97	0.99	—	—	—	34
0.80	0.82	0.87	0.90	0.94	0.97	0.99	—	—	—	35
0.79	0.81	0.85	0.89	0.93	0.96	0.99	1.00	—	—	36
0.79	0.80	0.83	0.87	0.91	0.95	0.97	0.99	—	—	37
0.78	0.79	0 82	0.85	0.89	0.94	0.96	0.98	—	—	38
0.78	0.79	0.80	0.83	0 87	0.92	0.95	0.97	—	—	39
0.77	0.78	0.79	0.82	0.86	0.90	0.93	0.96	—	—	40
0.77	0.78	0.79	0.82	0.85	0.89	0.92	0.95	—	—	41
0.77	0.77	0.79	0.81	0.84	0.88	0.91	0.95	—	—	42
0.78	0.77	0 78	0.81	0.84	0.88	0.91	0.95	—	—	43
0.78	0.77	0.78	0.81	0.83	0.87	0.90	0.94	—	—	44
0.78	0.77	0.78	0.80	0.83	0.86	0.89	0.93	0.96	0.99	45

TABLE II.

VALUES of log sec η compiled from the formula sec η = $\frac{i(\phi) - (\theta)}{\tan\phi - \tan\theta}$ when $\theta = 0$.

ϕ	log sec η	ϕ	log sec η	ϕ	log sec η
°		°		°	
1	0.00011	26	0.01634	51	0.08451
2	0.00012	27	0.01775	52	0.08941
3	0.00018	28	0.01924	53	0.09459
4	0.00033	29	0.02080	54	0.10004
5	0.00055	30	0.02246	55	0.10579
6	0.00081	31	0.02418	56	0.11187
7	0.00109	32	0.02601	57	0.11829
8	0.00142	33	0.02792	58	0.12510
9	0.00180	34	0.02993	59	0.13230
10	0.00224	35	0.03204	60	0.13993
11	0.00272	36	0.03425	61	0.14802
12	0.00324	37	0.03658	62	0.15668
13	0.00381	38	0.03902	63	0.16579
14	0.00444	39	0.04158	64	0.17561
15	0.00511	40	0.04427	65	0.18592
16	0.00585	41	0.04709	66	0.19701
17	0.00662	42	0.05005	67	0.20886
18	0.00746	43	0.05315	68	0.22158
19	0.00835	44	0.05644	69	0.23520
20	0.00931	45	0.05987	70	0.24986
21	0.01031	46	0.06347	71	0.26566
22	0.01140	47	0.06726	72	0.28271
23	0.01254	48	0.07125	73	0.30118
24	0.01373	49	0.07545	74	0.32124
25	0.01500	50	0.07987	75	0.34286

NOTE.

In the above very interesting and instructive article Major Hickman makes some remarks about my tables of 1900 which I am unwilling to let pass without some explanation on my part. I have claimed for my tables that, in using them for our standard projectiles, namely, those having ogival heads of two calibres radius, the coefficient of form is practically *unity* for all ranges. And, furthermore, that when the head of the projectile differs from the standard, if the coefficient of form be determined by experiment for a particular gun and range, it may be employed without change, in connection with the tables, for all other ranges adapted to the gun. These claims I have verified by comparison of calculation with observation in a good many cases.

For example, in the introduction to the tables I have compared calculation with observation: 1. For the Krupp shot fired in presence of the Emperor, in 1892. The coefficient of form in this case was unity. The angle of elevation was 44° and measured range 22,120 yards. The tables give 22,138 yards, or 18 yards in excess of the actual range. 2. For the so called "jubilee" shots. These were fired at angles of elevation of 40°, 35″ and 30°, and the coefficient of form was taken in each case at 1.18. The computed differ from the observed ranges by considerably less than one per cent. 3. For many other examples found in the introduction to the tables, but chiefly in the Handbook. for angles of elevation ranging from 5° to 45°, in which the difference between computation and observation is generally much less than one per cent.

These claims which I have made for my tables are not admitted by Major Hickmann to be true for English guns and projectiles, and he gives an example on pages 150 and 151 to illustrate their error. This example I will work out in my own way and leave the reader to judge for himself.

The data are:

Gun,	4-inch Q. F.
M. V.,	2237 f. s.
Thermometer,	65° F.
Barometer,	29.97 inches.
Weight of shell	25 pounds.

(*a*) Angle of departure 5°. Observed range 4360 yards. Observed time of flight 9.75 seconds.

(*b*) Angle of departure 20°. Observed range 9090 yards. Observed time of flight 30.7 seconds.

The projectile of this example has an ogival head of 2½ calibers radius, and therefore the coefficient of reduction to be used with my tables is less than unity. Its value, determined by Problem III, page 44, of Handbook, is 0.9422. We also have $\frac{\delta_1}{\delta} = 1.010$. Therefore the ballistic coefficient is

$$C = \frac{1.010 \times 25}{0.9422 \times 16} \times f$$

or

$$\log C = 0.22400 + \log f.$$

For the 20° elevation shot we find

$$\log f = 0.03895$$

and therefore

$$\log C = 0.26195$$

$$\log \sin 2\varphi = 9.80807$$

$$\log A = 9.54612 \;\therefore\; A = 0.35167$$

$$\therefore Z = 14900 + \frac{100}{459}\left\{0.37 \times 2007 + 35167 - 35813\right\} = 14921$$

$$\log Z = 4.17377$$

$$\log C = 0.26195$$

$$\underline{\log \tfrac{1}{3} = 9.52288}$$

$$\log X = 3.95860 \;\therefore\; X = 9091 \text{ yards.}$$

This value of X agrees of course with the observed range because the coefficient of reduction (0.9422) was deduced from it. We will now see what range this same coefficient of reduction will give for an angle of departure of 5°.

In this case we find

$$\log f = 0.00396$$

$$\log C = 0.22796$$

$$Z = 7589$$

$$X = 4276 \text{ yards.}$$

This is less than the observed range by 82 yards. The computed and observed ranges would agree by assuming a jump of 10′, which is certainly not an unreasonable assumption.

Major Hickman has computed by Bashforth's tables, the range, time of flight, angle of fall and striking velocity for the English 15-pounder Q. F. gun, for five different angles of departure for which the ranges and times of flight had been observed. As this forms an excellent basis of comparison I will make the same computation by means of my tables and formulas. The data are :

Diameter of projectile	3 inches.
Weight of projectile	14.375 pounds.
Barometer	30.50 inches.
Thermometer	34 degrees, F.
Muzzle velocity	1609 f. s.

The coefficient of reduction, determined by measuring the velocity at two points 1300 feet apart is

$$\beta c = 0.98.$$

From Table VI, we find

$$\frac{\delta_1}{\delta} = 0.934.$$

We therefore have for the ballistic coefficient (uncorrected for altitude)

$$C = \frac{\delta_1}{\delta} \frac{w}{\beta c d^2} = \frac{0.934 \times 14.375}{0.98 \times 9}$$

$$\therefore \log C = 0.18249$$

The angles of departure for which the elements were computed, corrected for depression of target and jump of gun, are 2° 25′, 5° 21′, 8° 19½′, 12° 18½′ and 16° 33½′.

In making the computations I have used the above value of log C throughout, correcting it, however, for altitude for the three longest ranges. I will give for comparison, the entire work for 2° 25′, 8° 19½′ and 16° 33½′:

$$\underline{\varphi} = \underline{2°}\ \underline{25'}.$$

$$\begin{aligned} \log \sin 2\varphi &= 8.92596 \\ \log C &= 0.18249 \\ \log A &= 8.74347 \\ A &= 0.05535 \end{aligned}$$

Now referring to the tables, page 56, we find by interpolation for $A = 0.05535$ and $V = 1607$,

$$\begin{aligned} Z &= 3290 \\ \log B' &= 0.1125 \\ U &= 1093 = V_\omega \\ T' &= 2.533 \end{aligned}$$

$$\begin{aligned} \log Z &= 3.51720 \\ \log C &= 0.18249 \\ \log 1/3 &= 9.52288 \\ \log X &= 3.22257 \\ X &= 1669 \text{ yds.} \end{aligned} \qquad \begin{aligned} \log \tan \varphi &= 8.6253 \\ \log B' &= 0.1125 \\ \log \tan \omega &= 8.7378 \\ \omega &= 3° \ 8' \end{aligned}$$

$$\begin{aligned} \log T' &= 0.4036 \\ \log C &= 0.1825 \\ \log \sec \varphi &= 0.0004 \\ \log T &= 0.5865 \\ T &= 3.86 \end{aligned}$$

$$\underline{\varphi} = \underline{5°}\ \underline{21'}.$$

For this angle of departure we find exactly as before,

$$X = 2986 \text{ yards}$$
$$\omega = 7^\circ\ 34'$$
$$V_\omega = 928 \text{ f. s.}$$
$$T = 7.85 \text{ seconds}$$
$$\varphi = 8^\circ\ 19\tfrac{1}{2}'.$$

For this angle of departure we will correct for altitude. When the range is known in advance, as in these examples, a near value of log f may be found as follows: We have *in vacuo* (Handbook, p. 231)

$$y_0 = \tfrac{1}{4} X \tan \varphi.$$

This formula gives fair results for trajectories in air when φ is replaced by $\frac{5}{4}\varphi$. We have then for a first approximation (Handbook, p. 42)

$$\log \log f = \log \tfrac{1}{4} X \tan (\tfrac{5}{4}\varphi) + 5.01765 - 10$$

or, reducing,

$$\log \log f = \log X + \log \tan (\tfrac{5}{4}\varphi) + 4.41559 - 10$$

In this example the observed value of X is 12,120 feet and $\frac{5}{4}\varphi$ is 10° 24′ 22″. Therefore,

$$\text{Const.} = 4.41559$$
$$\log \tan (\tfrac{5}{4}\varphi) = 9.26398$$
$$\log X = 4.08350$$
$$\log \log f = 7.76307$$
$$\log f = 0.00580$$
$$\log C_1 = 0.18249$$
$$\log C = 0.18829$$

This value of log C needs no correction. It will be noticed that we have designated by C_1 the ballistic coefficient uncorrected for altitude. The remaining calculations are the same as before, and we have:

$$X = 4045 \text{ yards}$$
$$\omega = 12^\circ\ 14'$$
$$V_\omega = 844 \text{ f. s.}$$
$$T = 11.53 \text{ seconds}$$
$$\varphi = 12^\circ\ 18\tfrac{1}{2}'.$$

The computations are precisely the same as have been already illustrated, and we give only the results:

$$\log C = 0.19364$$
$$X = 5202 \text{ yards}$$
$$\omega = 18^\circ\ 39'$$
$$V_\omega = 777 \text{ f. s.}$$
$$T = 16.11 \text{ seconds}$$
$$\varphi = 16^\circ\ 33\tfrac{1}{2}'.$$

For this angle of departure the table on page 56 is not sufficiently extended for this particular gun, though it can be used for much higher angles for the 5 inch gun and, of course, for all guns of superior calibre. The auxiliary tables constituting my Table II were computed for practical work and it was not considered advisable to enlarge the table simply to solve problems much more curious than useful, because the general table (Table I) can always be employed in such cases, and that, too, without excessive labor, as will now be shown: First compute log *f*. The observed range is 18630 feet and $\frac{5}{4}\varphi = 20^\circ\ 42'$

$$
\begin{aligned}
\text{Const.} &= 4.41559 \\
\log X &= 4.27021 \\
\log \tan 20^\circ\ 42' &= 9.57734 \\
\log \log f &= 8.26314 \\
\log f &= 0.01833 \\
\log C_1 &= 0.18249 \\
\log C &= 0.20082 \\
\log \sin 2\varphi &= 9.73747 \\
\log A &= 9.53665 \\
A &= 0.34407 \\
I(1609) &= 0.11239 \\
I(U_0) &= 0.45646
\end{aligned}
$$

$$
\therefore \frac{A(U_\omega) - 414.39}{S(U_\omega) - 6771.2} = 0.45646
$$

From this equation U_ω must be found by trial, as is fully explained on pages 56 and 57 of Handbook. We find:

$$
U_\omega = 694.136
$$

$$
\begin{aligned}
S(U_\omega) &= 18522.1 \\
S(V) &= 6771.2 \\
\log 11750.9 &= 4.07007 \\
\log C &= 0.20082 \\
\log \tfrac{1}{3} &= 9.52288 \\
\log X &= 3.79377 \\
X &= 6220 \text{ yards.} \\
I(U_\omega) &= 1.00778 \\
I(U_0) &= 0.45646 \\
\log 0.55132 &= 9.74140 \\
\log C &= 0.20082 \\
\log \sec^2 \varphi &= 0.03679 \\
\log \tfrac{1}{2} &= 9.69893 \\
\log \tan \omega &= 9.67793 \\
\omega &= 25^\circ\ 28'
\end{aligned}
$$

$$\begin{aligned}
\log U_\omega &= 2.84144 \\
\log \cos \varphi &= 9.98161 \\
\log \sec \omega &= 0.04439 \\
\log V_\omega &= 2.86744 \\
V_\omega &= 737 \text{ f. s.} \\
T(U_\omega) &= 15.348 \\
T(V) &= 2.838 \\
\log 12.510 &= 1.09726 \\
\log C &= 0.20082 \\
\log \sec \varphi &= 0.01839 \\
\log T &= 1.31647 \\
T &= 20.72 \text{ seconds.}
\end{aligned}$$

The value of $\log f$ computed by the formula

$$\log \log f = \log X + \log \tan \left(\tfrac{5}{4}\varphi\right) + 4.41559 - 10$$

is sufficiently accurate except for very long ranges, and for angles of elevation exceeding about 12°. In the example just worked out $\log f$ computed for two-thirds maximum ordinate is

$$\log f = 0.01868$$

from which the $\log f$ we have used in this example differs so slightly that it is not worth while to make any correction, especially as the mean height of a trajectory may not be exactly two-thirds the maximum ordinate, as it is *in vacuo*, though many comparisons show that it is nearly so.

I have collected the preceding results of computation into the following table for comparison with observation and with Major Hickman's calculations.

Angle of Departure.		Range, Yards.			Time of Flight.			Angle of Fall.				Remaining Velocity.	
		Observed.	Hickman.	Ingalls.	Observed.	H.	I.	H.		I.		H.	I.
°	′							°	′	°	′		
2	25	1661	1673	1669	4.00	3.88	3.86	3	11	3	8	1076	1093
5	21	2955	2958	2986	7.98	7.85	7.85	7	40	7	34	911	928
8	19½	4040	4027	4045	11.77	11.56	11.53	12	25	12	14	826	844
12	18½	5194	5185	5202	16·45	16.06	16.11	18	42	18	39	764	777
16	33½	6210	6209	6220	21.13	20.74	20.72	25	45	25	29	720	737

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NOTES ON RAPID-FIRE FIELD ARTILLERY.

TRANSLATED FROM THE FRENCH BY CAPT. W. W. GIBSON,
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NOTES ON THE CONSTRUCTION OF ORDNANCE: NO. 79.
Washington, April 1, 1901.

III.—RAPID-FIRE FIELD ARTILLERY OF EUROPEAN ARMIES, 1900.

[From Publication of R. Chapelot & Co., Paris.]

(Concluded.)

ITALY.

PLAN ADOPTED.—According to the "Revue D'Artillerie" of May, 1898, the Italian Government opened, in 1897, a competitive trial for the selection of a rapid-fire field artillery material. At the same time the artillery establishments at Naples and at Turin were invited to study a new material which would satisfy modern conditions in the best possible manner. The six models presented have not given satisfactory results, and the trial will probably be made all over again. It does not seem from present indications that the Italian artillery has the intention of replacing at the present time its old material. This material is composed of guns of 7-centimeter caliber for 84 batteries of field and mountain artillery. The committee of the Italian Chamber of Deputies have decided that this material, which is twenty-five years of age, must be gotten rid of as soon as possible and must be replaced by a rapid-fire material of new model, which the minister of war will adopt as soon as the trials have been concluded. Material of 9 centimeter caliber has been provisionally kept, and 201 batteries are provided with it. It has been essentially modified so as to properly fulfill its rôle in modern warfare. It was a question of adopting some very simple arrangements for permitting the proper use of these pieces, whose transformation is now in progress. It is reported that competitive experiments have been made with three systems of breech mecanism and firing apparatus intended to do away with the primer. These trials, which took place in March, 1898, with guns of 9-centimeter, have given very satisfactory results as regards the increase in the rapidity of fire. This increased rapidity was due to a great extent to a trail brake. It appears from various sources of information that a mixed solution has been adopted for the

Italian Artillery. On the one hand, the material of 7-centimeter will be replaced after a brief delay by a rapid-fire material completely new, of a model soon to be adopted. On the other hand, the material of 9-centimeter will be converted into a rapid-fire material and kept in use for some time yet. The commission has proposed the extraordinary credit of 15,500,000 francs to be divided among a number of financiers as soon as the new material has been definitely chosen.

RUSSIA.

Studies and Experiments.—The first experiment made in Russia for the selection of rapid-fire material was in charge of General Engelhart. It resulted in the replacement of the "rigid carriage," model 1877, by a carriage, model of 1895, which has an elastic trail spade and rubber cushions, which bring the carriage back to battery after a recoil of 0.3 meter. The rapidity of fire was thus doubled. This was a very simple carriage, has given excellent results, and is quite suitable to the climatic conditions. The General, nevertheless, has continued his researches, and a recent note in "l'Invalide Russe," gives a detailed description of the field material, which he is constructing in the Government shops and testing in comparison with the material presented by the principal foreign establishments. He prefers rubber to metallic springs, whose action is not always regular, and to pneumatic brakes whose mechanism is very little known in Russia and which are not suited to the climate. The Engelhart carriage resembles in its general characteristics the Nordenfelt carriage; a small moveable carriage fixed rigidly to the wheels. Rubber springs limit the recoil and bring the piece back to battery. A hydraulic mechanism deadens the shocks and regulates their action. This carriage is much longer than the carriage in use up to that time, in view of the increase in the initial velocity which is no longer 450 meters, but 600 meters. This length is in some way proportional to the initial velocity, to which the Russian general desires to sacrifice nothing. To avoid the fault found with Russian shrapnel, of having a feeble action at distances greater than 3,000 meters, the Russian General admits that it is necessary to increase the initial velocity and consequently to use carriages of much larger dimensions than formerly. It is seen then that in the construction of this new carriage General Engelhart has taken a personal interest. Moreover, he gives a preference to caissons with two wheels over caissons with four wheels for the following reasons: With rapid-fire artillery it will be necessary to increase the ammunition supply available. Now, with caissons with four wheels and six horses this increase of the ammunition supply can not be realized without increasing the actual number of artillery teams. It would not be the same with caissons with two wheels and two horses. In short, a caisson with six horses transports 80 projectiles of 6½ kilograms in weight, while three two-wheeled caissons with six horses transport 120 or one-half more. The General proposes to reduce the number of pieces of the battery from eight to six. There would thus be twelve available horses which could be utilized for these two-wheeled caissons. The ammunition supply to the battery would thus be increased by 240 projectiles with the same number of horses and the new battery of six pieces would have more efficiency and could fire more projectiles in the same time than the present battery. As a term of comparison the material which is to be replaced by rapid-fire material could fire four rounds a minute. If metallic cartridges were used this could be increased to six rounds. "The French carriage (according to General Engelhart) allows 22 shots a minute. My own, with perfect pointing, only gives 16 shots a minute, and if firing in zones is admitted (systematic firing, both in direction and in range) used by the French artillery, firing which does away with the necessity of repointing after each shot, I estimate that my carriage will not be inferior to the French." Below are given the principal data regarding rapid-fire material determined by General Engelhardt for the Government factories:

Caliber	millimeters...	76
Weight of projectile	kilograms...	6.3
Initial velocity	meters...	600
Weight of piece	kilograms...	276
Weight of gun and carriage	kilograms...	1,720
Number of rounds fired a minute		14
Number of cartridges carried by limber		36

Other guns, moreover, have been experimented with. A dispatch from St. Petersburg recently announced that the minister of war was having a study made at the present time of a new gun invented by a Russian lieutenant. The invention consists in a very great improvement on the Canét rapid-fire gun. This new gun can fire 20 shots a minute. Nevertheless everything leads to the belief that if Russia determines to change the rapid-fire material which it now possesses, and which was the first actually in service, it will be to adopt the system of General Engelhart indicated above, but it seems at the present time that there is no hurry about the adoption of a new system.

NORWAY.

Order of Trial Batteries.—According to "L'Allgemeine Schweizerische Militärzeitung" of the 29th of July, Norway, after having experimented with different recent models of rapid-fire guns for its field artillery, has decided to order four batteries of the Schneider-Canét type from Creusot. "This resolution," says the Swiss journal, "is to be noted, for the authority of the Norwegian commission on such subjects is well known. It particularly interests us because the military organization of Norway resembles the Swiss to a large extent. As the Swiss commission, which has undertaken the reorganization of the field artillery material, is at present occupied with experiments for the selection of a new gun, the resolution taken by Norway for its artillery will have a certain influence with this commission."

SWITZERLAND.

Order and Projects.—Switzerland has been for a long time considering the adoption of a rapid-fire gun. Since 1896 the Federal Government has been making a study of the conditions which such material should fulfill, and have summed up the requirements as follows:

Caliber	millimeters	75
Weight of the projectile	kilograms	5.8
Initial velocity	meters	500
Number of shrapnel balls		263
Length of the gun	meters	2 to 2.2
Weight of the gun with mechanism	kilograms	250 or 300
Weight of the carriage, equipped	kilograms	320 or 270
Weight of the piece unlimbered	kilograms	570
Weight of the limber with ammunition	kilograms	570
Weight of the gun and carriage, equipped	kilograms	1,140
Number of rounds carried by the battery		1,056 or 1,152
Number of rounds per piece		176 or 192

In 1898, experiments were made at the firing ground at Thoune, in presence of a special commission, with four models presented by Creusot, Saint-Chamond, Krupp, and Cockerill. The commission gave the preference to the Krupp material. Six pieces of this model were ordered with a view of forming a battery to be used in 1899 in experiments on a large scale. Nevertheless the commission continues to experiment with a carriage built by the workshops of the Federation and to continue tests with the Nordenfelt breech mechanism. Finally, studies and experiments will be made regarding the powder to be used in the new pieces. The Federal Council estimates that 17,000,000 to 18,000,000 francs will be necessary to provide the field and mountain artillery with rapid-fire material, and for the first supply of ammunition. The military department will complete in four batteries for mountain service, which are at present in existence. We will give some information upon the Krupp material spoken of before: The gun is 75 millimeters in caliber and 2.1 meters long and weighs 410 kilograms. The breech mechanism resembles that of the new gun, and as a whole differs very little from this latter. The projectiles, of 6½ kilograms in weight, consist of shrapnel and ring shell. The shrapnel contains 250 lead balls weighing 11 grams each. The projectiles are enclosed in a metallic case and fired with a powder charge of ½ kilogram smokeless powder. Last February the experimental committee made experiments with guns of various systems and of improved construction. It is stated that pieces in which the gun slides during recoil upon a fixed carriage, allow increased rapidity of fire, but are of too complicated construction for field service. It has fixed its attention upon an improved Nordenfelt-Cockerill model without hydraulic brake, but with a shoe mounted on an arm fitted with springs of a very ingenious system which absorb the recoil. A battery of pieces of this type has been ordered and is to be tried next autumn in competition with the Krupp battery ordered two years ago.

*Switzerland.**—Postponement of the adoption of the Field Material, Model 1901—New trials of Rapid-fire guns.

"We had announced that after long trials the Swiss Federal Council had proposed to the Federal Assembly the adoption of New Field Material, Model 1901 (Krupp system), and we had given the principal data as to this material.

"The proposal of the Federal Council raised quite a storm in Switzerland. A very lively discussion was started by the press and it was decided that the members of the parliamentary commission charged with the examination of the question should attend firing trials of the Krupp Material at Bière on May 31.

"The result of these trials must have been unfavorable, for contrary to what might have been expected in view of the advanced state of the question in Switzerland, they resulted in a postponement."

This is what is stated in the "Révue Militaire Suisse," June, 1901:

"As has been announced, the military committees of the Chambers on the 31st of May attended the firing trials at Bière of the new Krupp Field Artillery Material for the adoption of which a credit of seventeen millions had been asked by the Federal Council. The deputies did not find that this material showed a sufficiently marked improvement over the old to justify an expenditure of this importance, especially in view of the recent and greatly improved material which is now being constructed. The Commission has requested the Federal Council to have *new trials made of pieces with recoil on the carriage*, and to compare them with pieces having elastic trail spades. It proposes a credit of 200,000 francs to cover the expenses of these trials. If any further amount is required it will be included in the ordinary appropriation bill for 1902. It is certain that these credits will be granted. The Commission of the Council of States will undoubtedly decide in the same way as that of the National Council.

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* Extract from the *Révue d'Artillerie*, July, 1901.

"This solution is very fortunate; it was welcomed in Switzerland with relief. It is said there is no danger in the delay, but there would have been a lack of foresight in going to such considerable expense for the material proposed (Krupp) *which would have to be replaced in a few years.*

"Let us hope that the new trials will be studied without prejudice and that we will succeed in providing our country with artillery on a par with that of our neighbors."

If we consider what has just taken place in Switzerland in connection with similar facts elsewhere; purchase by England of rapid-fire material; order by Spain of 120 rapid-fire guns, as against only 24 with accelerated fire; the tendency in Norway toward rapid-fire material; postponement by Austria of the decision as to a new field gun, we can readily conclude that at the present moment a sudden change in favor of *material with recoil on the carriage* is taking place, searching experiments and prolonged use having demonstrated on the one hand that such material was the only one capable of furnishing really rapid fire, and on the other hand that it was possible to construct pieces of the nature with all the strength desirable.

SUPPLY OF AMMUNITION.

MEANS EMPLOYED OR PROPOSED.—The adoption of rapid-fire artillery has, in consequence, caused a considerable increase in the expenditure of ammunition and the means of remedying the difficulty is a very important and difficult problem. Since the adoption of the rapid-fire musket for infantry it has been found necessary to treble the number of wagons carrying the ammunition, and yet the decrease in the weight of the cartridges affords much more material relief than that which results from a decrease in the weight of artillery projectiles. Advantage was taken of the reconstruction of the material to diminish the weights of carriages without affecting their strength, so that each of them can transport a much greater quantity of projectiles, first, by reason of the diminution in the weight of the projectiles, but this was only a partial remedy. It may be that rapid fire with these guns, the same as with infantry rifles, will be the exception, and that it will be necessary to make use of it only in well determined cases such as against very prominent objects, within good range; in other words, when it is certain that this fire will give good results. That brings us back to the principle that the new artillery should economize its ammunition to lavish it if necessary for a good purpose. But this will not prevent the expenditure of ammunition from being greater than formerly, and it would be well to see that it is not lacking in id cases where the artillery will be able to make good use of it. It is necessary, in consequence, to increase the number of ammunition caissons of the first line. But without considering that we are not always sure of being able to provide for our needs so far as horses are concerned, it is impossible to allow of a new lengthening of the columns, as the author of a study on the organization of rapid-fire artillery, December, 1896, has proved. There would be reason consequently for reducing from three to two the number of batteries, making this reduction in the number of batteries and not in the number of pieces of a battery. This is a solution which appears quite practicable, since even with this reduction in the number of batteries, effects very superior to those obtained by the old artillery material can be obtained. It has been also noted that the lengthening of the column can be diminished and the number of horses reduced by the application of automobiles for the transportation of parks and heavy material. Great progress has been realized in the matter of mechanical traction and very searching experiments made, so that we can judge of the results and see if we can derive any profit from them. It is evident that in the present state of the question of the employment of automobiles can not be thought of for the service of the first line, but it seems that nothing prevents their being advantageously utilized for the transportation of parks and convoys. It is just to add that studies are being made in this direction and the technical commissions are following the experiments along this line. The Grand Duke Vladimir of Russia has even proposed to drag the guns and caissons of the first line with automobile limbers. The horses could then be reserved for the cannoneers and for helping over difficult ground. It ought to be noted in this connection that Colonel Renard in following his studies and experiments to obtain as light and powerful a motor as possible for aerial navigation, has succeeded in constructing a machine applicable both to maritime navigation and road traction. A motor of this kind towing a train of thirty carriages will be tried this year during the grand maneuvers of the army of Beauce.

CONCLUSIONS.

At the present time only Germany and France have adopted a new and complete rapid-fire field artillery fire. Russia has been contented with modifying its carriages. Austria and Italy have confined themselves, up to the present time, to modifying their guns so as to increase the rapidity of fire. But all these powers, including England, have not ceased to pursue studies and continue experiments with a view to the adoption of a new model field gun. For the greater part the experiments can be considered as having given definite results, and the question of the necessary credits is the great cause of delay in the fabrication of the new material. For these reasons, powers whose finances are involved, have remained in the rear of the movement. We have given, at the beginning of this study, the general principles which appear to have prevailed in the adoption and construction of the new material. We have indicated, in passing, certain consequences which will result from its adoption, without dwelling upon the question of reorganization of the personnel, which has given rise to heated discussions and which, we hope, will end by receiving the most satisfactory solution for the good of the army. It is much to be desired that the mystery which, with some reason, surrounds our new material should be removed as soon as possible, now that there is no longer any fear that foreign armies will endeavor to copy our system. On the contrary, it is of the greatest interest to the country and to the army to thoroughly understand it, in order to have all the confidence in it which it deserves and to know from the start all the advantages which can be derived from it. We have not spoken of the great changes which the entrance into line of battle of this new material will cause in tactics. It is known that rapid fire facilitates what is called "tir par rafales." that is to say, a regulated fire of great rapidity and of short duration. It should be stated that until the artillery ceases its fire no troops can move within the radius of efficiency of its projectiles. There will consequently result a formidable artillery duel between the two opposing forces, until one of the two has been able to silence the fire of the other. It will be a struggle of great intensity, of which the battles of the past can not give any idea, and which may be unfortunately terminated for one of the two artillery forces, not for lack of personnel, but for lack of ammunition. Before entering upon such a struggle it would be advisable to take great care, not only in the choice of excellent positions, but also to be sure that a proper supply of ammunition is on hand to bring the battle to a successful conclusion. One can judge, then, of the question of ammunition supply. Under these conditions it will naturally be necessary, in order to obtain superiority over the enemy, to endeavor to bring into line a larger number of pieces provided with a sufficient supply of ammunition, an advantage as much due to the judicious choice of position as by the well studied employment of an arm which at the present time possesses a marvelous efficiency at all battle distances. Further, as regards the material, many points do not appear to have been yet completely determined, and will probably receive different solutions. Thus, there is not an agreement everywhere on the best system of carriage and of brake, on the best projectile and the best powder, on the mode of ammunition supply, on the conditions and rapidity of fire, on the use of shells, etc. Nevertheless, all of the great powers will not delay long in procuring a field artillery material possessing practically the same qualities, although differing in certain features. On the other hand the new piece, being limited to the roads, can not, in spite of its mobility and lightness, take the place of a mountain piece, which has to be put in position in the most elevated valleys, and upon heights to which artillery can only be brought on the backs of mules. Nevertheless, a very considerable advantage has been derived from adopting the same caliber and same projectile as for the field artillery, so that the arrangements for a supply of projectiles will be facilitated. To conclude, we insist upon this point: that whatever may be said to the contrary in foreign countries, our new field artillery material is ready to engage with advantage, from all points of view, with that of other European countries. This is what General Dragomiroff says regarding the superiority of our gun over the German gun: "The new German artillery is already out of date. The experience of the one, whether for good or for bad, afforded the last comers a decided advantage. Profit was derived from the results obtained, thanks to the genius of the French artillery. They have obtained such a rigidity of carriage that a piece of money placed on the wheel on a circle remains in place after an indefinite number of rounds. The cannoneers can remain seated upon the carriage during fire and perform their duties without the least inconvenience. The extreme rapidity of fire counteracts the movement of animate objects, for these objects are instantly reached in their march by the stream of fire which pursues them. The fire, therefor, against movable objects ceases to be distinct from fire against fixed objects." Moreover, as the French artillery are not dependent upon any foreign engineers in the service of their artillery, the secret has been well kept.

IV.—RAPID-FIRE FIELD ARTILLERY.

[Extract from the "Revue D'Artillerie," February, 1901.]

We have referred in a preceding article to the study on rapid-fire guns published by Lieutenant Colonel Stang, of the Norwegian artillery. This very remarkable study comprises a certain number of interesting details upon the comparative trials in Norway of the field-artillery systems of Hotchkiss and Krupp and the Nordenfelt, in which the carriages are of the rigid type (guns with accelerated fire), and the field artillery material with long recoil of gun on carriage of Ehrhardt and Schneider-Canét (rapid-fire guns). It states in a very clear manner the peculiar characteristics of these various systems, and, by a few simple calculations, the advantages which the systems of long recoil present can be seen. This study is of peculiar value on account of the personal position of Lieutenant Colonel Stang, who was able to follow very closely the trials in question, and from the fact that Norway, not fabricating its own material, can more freely exercise its choice among all systems actually under construction in Europe. We have thought it would be interesting to give our readers a very full translation of this work while leaving to the author the responsibility for his assertions, particularly those concerning the question of recuperators.

The numerous systems of artillery belong to two distinct groups, toward which the development of rapid-fire artillery has tended, neither of which has yet obtained the unanimous preference. In the "rigid" system (without recoil of gun on the carriage) an endeavor was made to reconcile rapidity of fire with the maximum of simplicity, strength, and lightness; but to realize these desiderata it was necessary to give up the idea of obtaining immobility during firing, which many considered as the indispensable condition of accuracy and rapidity of fire.

In the type having a long recoil on the carriage, this mobility, on the contrary, has been obtained somewhat at the expense of simplicity and strength, which very many authorities consider indispensable qualities for field artillery material truly worthy of this name.

GUNS ON "RIGID" CARRIAGES.

The Hotchkiss rapid-fire gun very well represents this type, for it combines in a high degree the desired qualities in this type of guns, simplicity, strength, and lightness; but as it does not essentially differ from the former material used, except by the use of a trail spade and of a rapid-fire mechanism, it does not fill the demands that are imposed to-day on rapid-fire guns. The most perfect representatives, and really the most valuable of the first group, are the Krupp and Nordenfelt systems, in which the carriage as a whole moves to the rear on the discharge of the piece. In the Krupp system, the recoil is limited by a rotary spade with springs, which sinks into the ground and returns the carriage to the front in virtue of its elasticity as soon as the recoil is finished. In the Nordenfelt system, the carriage recoils, moving up on wheel shoes in the form of wedges, which also take hold of the ground. When the recoil is finished, the carriage returns to its place, rolling down the wedges. These two systems are simple and strong; the details, particularly for the Krupp gun, have been so well worked out that the service of the gun is both easy and rapid. Their weights are kept within very reasonable limits, which do not exceed 950 kilograms for the gun unlimbered, with a projectile of 6½ kilograms in weight and an initial velocity of 500 meters. But in both cases the carriage is so unstable that the cannoneers can not remain in their places during the firing, and when the conditions are slightly unfavorable the piece experiences such lateral shocks that after each discharge it is necessary to move the trail to correct the pointing in direction. The spring spade of the Krupp system acts very badly on hard ground. It constantly moves during the firing, and the carriage, in returning to battery after the recoil, never resumes its original position. Besides this, the spade rarely finds a solid point of support which can hold it throughout the firing. It is useless to hollow out a furrow for it, where it could be anchored at the first discharge, for there is no certainty that it will take that position and regain its point of support at the following discharge. In soft ground the spade buries itself so rapidly that pointing in direction becomes extremely difficult. In light soil the resistance is so small that the carriage move to the rear more and more at each discharge. In firing on sloping ground it often happens that the spade does not return the piece completely to battery. The carriage then descends a little more at each firing. The Nordenfelt system does not behave well on hard ground; the shoes do not sieze hold of the soil sufficiently to remain immovable during firing. According as one or the other of these shoes meets more resistance the trail is thrown to one side or the other, the piece is thus violently turned from its proper direction and the cannoneers are liable to be hustled from one side to the other by the trail. Moreover, the general form of the shoe, the tie-rods, and the chains causes a certain amount of trouble during the march. Nevertheless, the Krupp system, as well as the Nordefelt carriage, being provided with apparatus for pointing in elevation and direction, which are very easily manipulated, and the breech mechanisms being simple and handy, in spite of the instability of the piece eight to nine shots per minute can be relied on under normal conditions.

PIECES WITH LONG RECOIL ON CARRIAGE.

Among the materials of the second group, with long recoil on carriage, we ought to place in the first class the Schneider-Canét and the Ehrhardt systems. In these two systems the carriage and the wheels remain fixed at the discharge of the piece, while the gun recoils with certain parts of the carriage which are rigidly connected with it. This recoil, regulated by a hydraulic brake, is sufficiently prolonged for the force exerted upon the trail spade to be relatively insignificant, and the tendency to jumping is notably diminished. The gun is brought back into battery after firing, in the Schneider-Canét system by compressed air, and in the Ehrhardt system by springs. In both cases the carriage is so stable that the cannoneers can remain seated there during the firing (Plates A, C, and D). The arrangements for sighting and the apparatus for pointing in elevation and direction are attached to the fixed parts of the carriage.* The gunner is therefore ablé to correct the pointing immediately after the discharge, and the cannoneers in charge of the breech can commence to open it before the gun has entirely returned to the firing position. It results from this that the rapidity of fire, under favorable conditions, is particularly

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* This is not exactly true for all models, the Ehrhardt, for example, for model IV (Fig B), which has a Corrodi sight fixed to the gun.

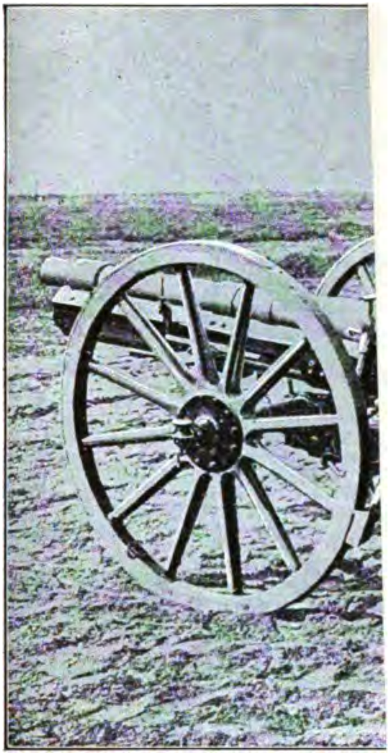

Fig. A.—Ehrhardt Rapid

Fig. B.—Ehrhardt Rapid

Fig

limited by the time that the gun takes to recoil and return to battery. The force which acts on the trail spade being relatively small, the latter can find a suitable support in different kinds of soil. In rocky ground a break or crack is often found which can furnish a sufficient supporting surface for the end of the spade. Even on ice covered with a layer of snow the spade of the Ehrhardt gun can find a sure point of support at the first discharge in a furrow traced by a pick. Finally, if the ground is hard and solidified, so that the spade can not effect an entrance there, it is very easy to hollow out a groove deep enough to furnish the necessary supporting surface. In light soil the spade does not enter as deeply, the force exerted upon it being less, and it thus remains motionless, without sinking any farther. With the two systems at Lexdalen, under unfavorable conditions, on ground hardened by frost scarcely covered with a thin layer of earth, an average rapidity of fifteen aimed shots per minute has been obtained.

ADVANTAGES OF GUNS WITH LONG RECOIL.

The type with long recoil has then the advantage over the "rigid" type of a greater rapidity of fire. But this extreme rapidity of fire being rarely employed, the important point is that in the two systems in question the gunner has plenty of time to point the piece accurately after each fire, without being hurried; in consequence, there can be obtained with the maximum efficiency per round, a rapidity of fire that can not be secured with "rigid" carriages without excessive work being brought on the personnel and by dispensing at each round with accuracy of sighting. The piece with long recoil on the carriage, as has been indicated above, depends much less upon the ground than pieces of the "rigid" type. The following objections have been raised to pieces with long recoil upon the carriage: (1) They do not possess the desired strength and simplicity. Leakage of the liquid in the cylinders occurs. If compressed air is used to bring the gun back to battery, leakages occur even more readily. If recuperator springs are employed, the brake has to be made so large that it is liable to be damaged by hits or by accidents. (2) The weight of these pieces is too great, for the long recoil of the gun necessitates such a construction of the carriage that there results an increase of weight. Moreover, many authorities believe that the carriage and gun ought to have a very considerable weight in order that the piece shall remain motionless during firing.

EXPERIMENTS MADE WITH GUNS OF LONG RECOIL.

The strength of the Schneider-Canét and Ehrhardt systems has been recently put to a very severe test during the trials which took place in Norway. Three hundred and fifty rounds were fired with each piece; then marching tests and transportation tests were given, first a long journey by railroad, then a marching test of 61 kilometers. The pieces were then unshipped, placed upon ordinary peasant trucks and carried into a mountainous country for 140 kilometers, during which journey they frequently upset and had to endure very hard treatment. Then came a new marching test of 98 kilometers; afterwards some more firing and a long journey by railroad; then a last marching test was made of about 100 kilometers over very difficult ground and under varying conditions. In the firing which was made the brake proved to be in perfect order. During these tests no leakage of liquid in the cylinders nor of air occurred. In order to see what effect the accidental loss of liquid or air would produce, the firing program embraced the following test: First, ¼ liter of glycerin was taken out of the cylinders. Upon firing, the length of recoil was increased by only a very insignificant amount (3 to 4 centimeters). One-quarter of a liter more was then taken out, making in all ½ liter. This had no other effect than of further increasing the recoil by a corresponding amount without, however, reaching the maximum limit of 110 centimeters. There is generally an exaggerated fear of the leakages in the brake cylinder. Now in this cylinder there is only a single packing around the piston rod, which can be made very simple and in such a manner as to be easily repaired. The liquid is compressed only during firing, and if a few drops are lost at this instant it has no practical effect. As far as air cylinders are concerned it is different; the packing is much more difficult to repair, and as the air is put in the cylinder at an initial pressure of 12 atmospheres it will escape continuously if there is the slightest leak. The returning of the piece to battery then by means of springs is considered more advantageous, although these take up a great deal more room and make the brake larger and heavier and render it liable to be hit by projectiles.*

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* It is seen that that the only reason which leads Lieutenant Colonel Stang to prefer the spring recuperator to the air recuperator is the fear of leakage which can take place in the latter. But this apprehension apparently disappears in the cases of the air recuperator, where leakage can occur with great difficulty and where the pressure can be kept up in case of leakage by means of a special arrangement. It ought to be remarked, moreover, that one of the great advantages which the air recuperator under high pressure has over spring recuperators is the possibility of obtaining a sufficient pressure to insure the return into battery in all cases. This depends upon the property which air under pressure presents of being by far the best of all springs for equal weights.

The opinion that the system with long recoil of gun on the carriage is necessarily very much heavier, is certainly erroneous. Undoubtedly the construction of the brake which distinguished this system, necessarily brings with it an increase of weight. The brake cylinder with piston and piston rod weigh about 40 kilograms; the recuperator springs 30 to 40 kilograms; and finally the parts which cover and protect the system may be estimated at a weight of 30 to 40 kilograms, making in all about 110 kilograms. The carriage ought, on account of the long recoil, to be a little longer than in the "rigid" system, but the strain it has to bear during firing being much less it can be built less solidly, so that it is not necessarily heavier. This increase of weight (which can be reduced one-half when compressed air is used as a recuperator) will be, however, compensated for by the fact that the strain supported by the carriage is decreased in an extraordinary manner, so that while preserving a sufficient strength, a much less massive construction can be given to this carriage than in the "rigid" system.

ORDNANCE OFFICE,
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A. R. BUFFINGTON,
Brigadier General, Chief of Ordnance.

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Recent Experiments in Attacking Armor with High-Explosive Shell.*

By E. B. Babbitt.†

Reprinted from Engineering News, November 21, 1901.

The struggle between the armor and the projectile is drawing to a close. The limit of flotation has practically settled the thickness of armor to be carried, and the manufacturers now bend their energies, with remarkable success it is true, to improving the armor. With all this, however, the projectile is in the lead, and has now brought to its assistance the valuable aid of high explosives.

The Ordnance Department of the Army has been experimenting for many years to secure a high explosive for a shell filler, and with varying success. The report of the Ordnance Board conducting these tests in 1883, 1884 and 1885, usually concluded with "burst at the muzzle" or "destroyed the gun". Naturally, then, the problem as it presented itself to them, was to secure an explosive that could safely be fired from a high-powered gun. As we approach it now, that is really but a corollary to the condition that it will not explode on impact on armor, as the shock in the latter case is so much greater.

When the Board of Ordnance and Fortification was organized, the tests with high explosives took a wider range, due partly to the larger fund at its disposal and partly to the increased activity of the manufacturers for a time. The subcommittee of this board considered at length this subject and reported:

It appears that the following points are to be investigated: (1) Which is the best explosive for use in shells. (2) Is an explosion of the first order, or detonation, assured with the different methods of loading proposed by the inventors to prevent premature explosion. (3) Will the explosive stand the friction due to rifled motion when loaded as proposed. (4) Will the explosive stand the shock of firing when loaded as proposed by the different inventors. (5) Will the igniting mechanism stand the shock of firing and the rifled motion without premature action. (6) Will the igniting mechanism act as desired. (7) Will the shell, without the igniting mechanism, explode on impact with water, with earth, with stone, with wood, or light iron, and with iron armor.

Considering these it appears: That the first is the summation of those that follow. The second, in its investigation, led to extensive sub-terra experiments which, while instructive, really led the investigators from the true scope, namely, to get an explosive that could be used in a shell. The third condition was quite a bugaboo, and comes to us even today. I have my doubts as to its importance.

In a moment of mental aberration, I devised a fuse depending for its action upon a plunger within remaining at rest while the envelope took up the rotation of the projectile. I had no doubt about this feature, but, wishing to investigate another, made such a plunger, supported, by the way, by an axial shaft, thus reducing the frictional moment, and fired it from a field gun into a sand butt. When recovered and opened—behold! the plunger had not moved in its housing. Thus ended a threatened revolution in the fuses of the world. As my brother officer, Captain Crozier, would say, "Ideas are cheap; worth about 25 cents a bushel"—when one is developed into something tangible it is priceless.

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* A paper read at the ninth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 14 and 15, 1901.

† Captain of Ordnance, U. S. A., officer in charge of experiments at Sandy Hook proving ground.

Of the remaining conditions, those regarding the fuse or firing mechanism are important, since in the later development a successful explosive waited on a satisfactory fuse.

At the time of this report, 1891, there were before the board, explosive gelatine, gun-cotton, emmensite, Schwalin mixture and Americanite. Of these gun-cotton alone is now considered as a shell filler, and then only wet and with a matrix. Between 1892 and 1896, there were tested in addition: Terrorite (N. G. and nitro ethyl and nitro methyl); rackarock, a sprengel safety mixture; ammonite, 90% ammonium nitrate and 10% mono-nitro-naphthalene; jovite, 87 NH_4NO_3 and nitro-phenols and nitro-naphthalene. None met with success. Between 1896 and 1898 the Ordnance Department experimented largely with gun-cotton, in various forms and degrees of moisture, and met with considerable success, thanks to a detonating fuse devised by Lieutenant, now Captain W. S. Pierce, Ordnance Department. In 1898, Thorite began its brilliant but short career. The sensitiveness of most of the high explosives brought forth during this period many novel ideas for firing them with safty, the most notable being the famous pneumatic dynamite guns, three of which were mounted on the Vesuvius, and were used at Santiago with so little effect. As late as August 23, 1899, a charge of 129½ lbs. of explosive gelatine was fired from a 12-in. service rifle using an Isham diaphragm shell. The explosion of this mass against a 12-in. plate failed, on impact, to rupture the plate but moved it bodily. More damage was done to a similar plate with a service armor-piercing shot uncharged.

With the reorganization of the Ordnance Board in 1899 was introduced the present system of investigation, which in its workings, has brought about conclusive results, and has, it is thought, given a most satisfactory explosive and fuse; in other words, a most powerful weapon for attack, superior to any possessed abroad of which we have any knowledge. I can do no better than quote the following reply of the Ordnance Board to a letter from the Chief of Ordnance asking about the status of the question of high explosives for shell:

"From the nature of the subject it is evident, and experience has amply demonstrated the fact, that the selection of a high explosive shell which shall be thoroughly efficient and yet safe, beyond any reasonable doubt, to store, handle and fire under all conditions of service, presents a most difficult problem which offers chances of failure at every step and can be considered solved only when these requirements are satisfactorily established by exhaustive tests. The destructiveness of the explosive makes it a constant menace to the men and material using it, and a perfected projectile involves not only the explosive but the fuse and the method of constructing the shell also."

A satisfactory high-explosive shell should fulfill the following requirements:

SAFETY AND INSENSITIVENESS.- (1) Should be reasonably safe in manufacture and free from very injurious effects upon the operatives.

(2) To warrant further test, it must show a relatively safe degree of insensitiveness in the impact testing apparatus used by the Department.

(3) Must withstand the maximum shock of discharge under repeated firings in the shells for which it is intended.

(4) Must withstand the shock of impact when fired in unfused shells as follows: (a) Field shell; maximum velocity against 3 inches of oak timber backed by sand. (b) Siege shell; against seasoned concrete thicker than the shell will penetrate, with remaining velocity for full charge at 500 yds. rauge. (c) Armor piercing shell; against a 7-inch tempered-steel test-plate in a 12-inch A: P. shell with a velocity just sufficient to penetrate.

DETONATION AND STRENGTH.—(5) Must be uniformly and completely detonated with the service detonating fuse.

(6) Should posess the greatest strength compatible with other necessary requirements.

STABILITY.—(7) Must not decompose when hermitically sealed and subjected to a temperature of 120° F. for one week.

(8) Should de preferably non-hygroscopic, and must not have its facility for detonation affected by moisture that can be absorbed under ordinary atmospheric exposure necessary in handling.

(9) Must not attack ordinary metals used in projectiles and fuses to an extent that cannot be prevented by simple means.

(10) Must not deteriorate or undergo chemical change in storage.

GENERAL CONDITIONS.—Loading must not be attended with unusual danger, and should not require exceptional skill or tedious methods. It is very desirable that the explosive be capable of compact loading, either by melting or compressing into solid blocks. It should be possible to procure the explosive quickly and in quantity in this country at a reasonable cost.

To carry out investigations covering all these conditions involved constructing a comprehensive scheme of test and the expenditure of much money. The object being to get the explosive through armor, the final test would naturally be a practical trial under service conditions. These costing from $3,000 to $5000 per round could be very few, and means had to be devised for an early elimination of those doomed to failure.

We, therefore, first determined: (1)The relative force (by calculation) for actual density of loading in shell; (2) specific gravity; (3) density of loading; (4) charge contained in 100 cubic inches; (5) approximate cost of charge; (6) ease of supply; (7) method of loading; (8) safety in manufacturing; (9) stability in heat test; (10) non-hygroscopic; (11) non-active on metals.

If the above were satisfactory the explosive was tested in an impact testing machine devised by Captain Dunn, a member of the board. In this is provided a shallow cup in an anvil capable of holding a few grains (by weight) of the explosive in such a manner as to prevent lateral expansion.

By noting the height of fall of a known weight, the relative sensitiveness is determined. It is of interest to know that, in every case, subsequent armor tests have borne out the conclusions reached with this little machine. Having once determined a limiting drop, below which an explosive would fail in a gun, it is easy to reject, without firing, all those below that limit, and indeed select only those approaching a higher drop limit that would indicate insensitiveness to impact.

A projectile acquires its velocity in passing over the entire length of the bore of a gun, but if stopped by an armor plate, is arrested in a very small fraction of the first distance. It is therefore, evident that the shock of impact is the severer test, and it is here that the tests become more interesting.

We have no means of determining the law of retardation in plate, so for comparison are forced to assume that it is constant over the path. Under this assumption, considering the length of column of the explosive in each service shell, and the armor against which it is tested, it can be shown that the shock to the explosive in a 6-pounder shell against a 3-inch nickel-steel plate is greater than in any of the service tests. For this reason, and on account of the relative inexpensiveness, the 6-pounder R. F. gun was selected for the prelimenary tests against armor. Standard plates 1 inch, 1½ inch, 2 inch and 3 inch, are used and firings made at each in order, till either the explosive bursts on impact, or successfully resists the highest plate. The results of the first series of tests following this mefhod are as follows:

SUMMARY OF TESTS OF 6-POUNDER STEEL SHELL CHARGED WITH HIGH EXPLOSIVES AND FIRED (UNFUSED) AGAINST STEEL PLATES OF VARYING THICKNESS.

PLATES.—Braced against 6-inch oack backing (110 feet from gun) with intervening clear space of 20 feet to sand butt in rear—so placed in order to observe action of shell after penetrating target, and to collect fired shell or their fragments from the butt. The following plates were used: Carnegie tempered (nickel steel) plates, 36 × 36 inches, 1, 1.5 and 2 incees thick; Fragments of mild steel plate, 3 inches thick; Carnegie tempered (nickel steel) plate 38 × 40 inches, 3 inches thick.

Table showing results of preliminary tests of high explosive 6-pounder shells fired against armor plates from 1 inch to 3 inches thick.

Shell charge.	No. of rounds.	Plate thickness, ins.	Action of shell.
Sand.......	2	1.5*	Penetrated target; recovered whole.
Black powder.	1	1.0*	Penetrated target and burst 4 feet in rear.
“ “	1	1.5*	Penetrated target and burst close behtnd.
“ “	1	2.0*	Penetrated target and burst 3 feet in rear.
No. 400 explo.	2	1.0*	Penetrated target and burst 30 ins. in rear.
“ “	1	1.5*	Penetrated target and burst close in rear.
Picric acid.....	2	1.0*	Penetrated; both had plug blown out between target and butt; low order of explosion.
“ “	2	1.5*	Penetrated; and deflected to sea, lost; other exploded violently in backing.
“ “	1	2.0*	Exploded in plate; point passed through; base was blown to rear over gun shelter.
Gun cotton.....	1	1.5*	Penetrated; recovered whole. Charge slightly set forward at rear.
“ “	1	2.0*	Penetrated; exploded in butt.
10% maximite.	1	2.0*	Penetrated; entered butt apparently whole; lost.
“ “	2	3.0†	One penetrated, recovered whole; charge not disturbed. Other stuck in plate, base imbedded 1.5 inches; charge slightly set forward at rear.
25% maximite.	1	1.5*	Penetrated; recovered whole; charge not disturbed.
“ “	1	2.0*	Same except charge slightly set forward at rear.
“ “	2	3.0†	One penetrated; recovered whole; charge slightly disturbed at rear. Other stuck in plate, head half through; not exploded.
Explosive “D”	2	2.0*	Penetrated: recovered whole. Charge slightly disturbed at rear.
“ “	2	3.0†	One, same as adove; other stuck in plate; broke in two across middle; explosive net ignited.

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* Tempered. † Mild steel plate.

PROJECTILES.—6-pounder A. P. shell, steel, for which the acceptance test requires penetration of a 3-inch mild steel plate, without fracture, base fuse dismantled and brass fuse stock cut off to be flush with the rear end of shell cavity when screwed home; hollow in stock filled with plaster of Paris. The projectiles were filled, flush with the inner end of fuse hole through base, with the following explosives: (1) Black musket powder, filled loosely into shell cavity—average charge 4 oz. (2) Rendrock Co.'s No. 400 explosive, heated to pasty condition, and tamped with wood stick in shell cavity—average charge 9.08 oz. (3) Picric acid, melted and poured into shell cavity—average charge 6.41 oz. (4) Gun-cotton pellets containing 15% moisture, loaded with matrix formed of 60 parts paraffine, 25 parts resin, and 15 parts beeswax—average charge 2.025 os. (5) 10% Maximite, melted and poured into shell cavity—average charge 5.85 oz. (6) 25% Maximite, melted and poured into shell cavity—average charge 6.075 oz. (7) Explosive D in pewder, tamped as well as possible with wood stick through fuse hole—average charge 4.375 oz.

It is seen from the table that the black powder, No. 400 explosive, and picric acid, all failed to penetrate the 1 inch tempered steel plate without explosion; some superiority for picric acid is only shown in that the explosion was less violent than with the other two. The 1.5-inch plate produced a violent explosion of picric acid as well as of black powder and No. 400 explosive. Gun-cotton passed the 1.5-inch plate test, but failed with the 2-inch plate. The two grades of maximite and explosive "D" passed the 2-inch plate test and also the test with the 3-inch mild steel to which they were subjected. A 3-inch tempered-steel plate was then mounted to give an extreme test for these explosives. The powder charge was increased to give a striking velocity of 1.920 ft. secs., with which four rounds were fired, and also two rounds fired with a charge giving a striking velocity of 1,970 ft. secs., viz.:

Velocity, 1,920 ft.-secs.

Shell charge.	No. of rounds.	Plate thickness ins.	Action of shell.
10% maximite.	1	3*	Struck squarely, point passed 4½ inches beyond front face of plate; shell in fragments, rebounded leaving clean hole; explosive ignited, as shown by cloud of smoke.
" "	1	3*	Point penetrated about 4¼ inches; shell rebounded 110 ft. badly set up; no explosion.
Explosive "D"	2	3*	One with same penetration as preceding; other striking somewhat obliquely, penetrated about 3 inches; both broken; explosive formed cloud of powder; not ignited.

Velocity, 1,970 ft.-secs.

Shell charge.	No. of rounds.	Plate thickness ins.	Action of shell.
25% maximite.	1	3*	Badly upset and broken on plate. Cup-shaped hole 1.5 inches deep. Explosive ignited, as shown by cloud of smoke.
Explosive "D"	1	3*	Same as preceding. except hole 1.7 inches deep; explosive formed a cloud of powder; did not ignite.

These tests led to the selection of two explosives, namely, maximite and explosive "D", as worthy of final test.

Owing to the impossibility of controling the explosives in an ordinary explosive chamber, fragmentation tests are made by burying the larger shell, fully charged and fused, about 10 feet in sand and firing the fuse electrically. Fragments are then dug out, weighed and counted. Careful search is made for any unexploded material. The following extracts from these fragmentation tests gives an idea of the results obtained.

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* Tempered.

(1) 12-inch A. P. shell. Maximite, buried 10 feet in sand; Frankford Arsenal A. P. detonating fuse.

	Lbs.	Oz.
Weight of empty shell and fuse	960	4
Weight of explosive charge	50	12
	1,011	0
Weight of metal recovered	827	7
Number of fragments counted	3,690	
Number of fragments, small pieces estimated	2,718	

(2) 12-inch A. P. shell charged with explosive "D," buried 12 feet in sand; Frankford Arsenal detonating A. P. fuse.

Weight of empty shell and fuse	915	4
Weight of explosive charge	57	12
	1,009	5
Weight of metal recovered	815	0
Number of fragments	850	

The first result quoted above is much above the average, and has not been duplicated. Indeed, there is a limit to the size of useful fragments. A large number of fairsized fragments driven with high velocity throughout the interior of a vessel would cause more damage than a much larger number of small fragments. Such a statement is always subject to modifications; if, for example, a shell should burst in a crowded part of the vessel as was the case in the turret of the Japanese flagship at the battle of the Yalu, the more violent explosion would be more disastrous.

Both explosives having met all requirements up to this point, there remained the final tests against armor. Twelve-inch armor piercing shot having sufficient velocity for penetration, are required to pass through a 12-inch face-hardened plate before the lot represented by the projectile is accepted. This was, therefore, adopted as the final tests for the explosives, namely that they must withstand the shock of impact of such a projectile on such a plate. It was led up to by firing first a 5-inch shell through a 3-inch tempered plate. Next, a 12-inch A. P. shell through a 7-inch tempered plate, and finally a 12-inch A. P. shot (capped) through a 12-inch harveyized plate. All the above were unfused, and, in every case, the projectiles were recovered and, later, fragmented to increase our data on this subject.

It should be stated that all armor plates are supported by having backings of oak strongly braced, and in rear of this is a large mound of sand in which the projectile finally comes to rest. At last the final test was reached. Imagine the tension as, from a safe distance, we stood with eyes to our glasses anxiously watching the distant field. The target a 5¾-inch tempered-steel plate, well backed with oak, defiantly faces the long slender 12-inch rifle. The red flag waves from the firing bomb proof. It is answered. The flag falls, a bank of smoke from the gun, a flash of light at the plate, a dense, black, foreboding mass of smoke interspersed with flying timbers and bits of plate, two mighty roars in quick succession, a sigh of relief and satisfaction from the observers, and, for the first ttme, a 12-inch armor-piercing shell, loaded and fused, has passed through heavy armor. While, later, heavier plates were used and the results therefore more satisfactory, the first success ever stands out most vividly in the minds of the experimenters. The official record of this test reads as follows:

No. 7. 12-inch A. P. shell charged with explosive "D," 58½ lbs. Weight of charged shell complete, 1,021 lbs. Fired March 27, 1901, with Frankford Arsenal detonating A. P. fuse complete against 5¾-inches tempered-steel plate, and detonated immediately in rear. Plate broken and carried forward with numerous fragments of shell.

Tests against 7-inch steel plates and 12-inch face-hardened plates followed with great success. Finally, encouraged by the successful results, a 12-inch A. P. shell (the test of which is a 7-inch steel plate) was fired against a 12-inch face-hardened plate. The record reads:

No. 11. 12-inch A. P. shell charged with explosive "D," 58.6 lbs. Weight of charged shell complete, 1,010 lbs. Fired May 17, 1901, with Frankford Arsenal detonating A. P. fuse complete against a piece of 12-inch face-hardened steel plate. Pressure in gun 20,000 pounds per square inch. Velocity about 1,875 ft. secs. Shell detonated in plate and completely demolished plate and backing—all backing carried forward and swept away. Fragments of plate were thrown to a distance of 200 to 300 feet, and gave evidence that the plate was penetrated by the shell.

In summing up the final tests we find:

	Explosive "D."	Maximite.
Shell fragmented by detonating fuse	8	11
Shell fired from gun unfused	13	12
Shell fired from gun fused	13	10
	34	34
Results entirely satisfactory with respect to explosive	34	33
Premature action of explosive, cases afterward remedied	—	1
Fused acted feebly—remedied	3	1
Fuses failed	1	—

Before closing, it is necessary to mention a most important factor in this success, namely, the fuse. But, of this, little can be said. It is the secret of all our triumphs, and as such is being carefully guarded. It, like the explosive, passed through various stages. It was tested separately for its power to detonate the shell charges; its power to resist shock of discharge and impact; and, finally, under service conditions. It had its failures in the early stages, but, thanks to the skill and energy of Captain Beverly W. Dunn, Ordnance Department, U. S. A., won out in the end.

One of the most serious questions connected with an armor-piercing fuse is its delay in action. Introducing, as it does, the time element, it is evident that an interval suited to light armor would not be satisfactory for heavy when the time of penetration is greater. As by far the greater part of a ship's protection is relatively light armor, a delay sufficient to cause detonation a few feet after penetration seems best. This gives us a burst when a shot is still in the 12-inch plate, but has penetrated.

I think I am safe in saying that the results just enumerated are unique, and so far surpass those previously obtained as not to admit of comparison with them.

Re-armament of the Artillery (Communication from the Swiss Military Department.)

From the Swiss newspaper, *Der Bund* No. 352 of Dec. 12, 1901.

In accordance with a detailed report by the Board for the re-armament of the artillery regarding the comparative trials with long-recoil guns of different constructions, and in accordance with a unanimous recommendation from the Board, the Federal Council has resolved an December 5th:

First. That an order be given to Krupp in Essen for a battery of four long-recoil guns after the system presented by that firm.

Second. That the Military Department be authorized to order a course of trials for a period of five weeks within the next year, and to procure the necessary ammunition for testing the said battery.

Third. That the Military Department also be authorized to procure one or two caissons, provided with all improvements until now tested.

This resolution was taken under the supposition, that the appropriation of 300,00 francs ($60,000) for the continuation of the trials, for which the Federal Assembly had asked in the Budget Bill for 1902, would be granted. This sum now being available, the continuation of trials will be conducted in accordance with the Federal Council resolution as above.

The scope of these trials is not only to test Krupp's long-recoil guns in battery, but especially also to compare them with the short-recoil (elastic spur) gun at first recommended.

A decision whether the short or long-recoil is to be preferred will only be reached after the conclusion of these trials.

It is already known, that Krupp's long-recoil gun has undergone competitive trials with and won over the long-recoil constructions of Creuzot, Skoda, Cockerill and Ehrhardt. Piorkowski.

Tests of Beardmore's Armor-plates.

From *Engineering*, London, January, 1902.

Messers. William Beardmore and Co., Glasgow, half of whose shares have been purchased by Messers. Vickers, Sons, and Maxim, Limited, an arrangement which must prove advantageous alike to the nation and to the parties immediately interested, have for some time been perfecting a process for hardening armor-plate which has given splendid results in recent tests. The one tested in the early days of the process, and the other a few months ago specially to determine the limits of resistance.

The earlier plate was attacked by a six-inch breech-loading gun firing Holtzer projectiles with a charge of 48 pounds of E X E Powder, the pressure varying between 15.2 and 15.5 tons. The backing was 4 feet, 10 inches at top and bottom and 5 feet, 10 inches in the center, and was secured by eight bolts. It will be seen from the tabulated results appended to the views that the crack from the bottom to the indent made by the first shot, was the result of the second round, and that the third round caused a crack from the point where the first shot struck lo the right edge of the plate, the same cracks being developed in the succeeding rounds; but otherwise the plate stood well, all of the projectiles being broken up.

The plate tried quite recently—8 feet, 6 inches by 6 feet, 6 inches—gave splendid results. It was made according to Beardmore's latest process, was 6 inches thick, and was attacked by a Vickers' 6 inches gun, with increasing charges, the idea being to acertain how much the plate could stand. The first round, with a striking energy of 2764 foot-tons, was broken up; nor did the second round have any effect. The third shot, of 2912 foot-tons, was similarly broken up, the point remaining fused in the plate. The fourth shot, at 3280 foot-tons, got further home, the penetration being about 3 inches, as compared with 2 inches in the previous round; and while the fifth round at the exceptionally high energy of 3550 foot-tons, got through the plate, it had all its energy spent, as the nose of the projectile is barely discernable through the back skin of the plate. No crack was made, so that the plate may almost be pronouned as invulnerable in ordinary conditions of warfare.

RESULTS OF TRIAL OF BEARDMORE 6-IN. EARLIER PLATE. ATTACKED BY 6-IN. GUN, FIRING HOLTZER PROJECTILES.

Round.	Elevation of Gun.		Pressures.	Point of Striking.	Effect on front of plate.	Result on back of Plate.	Effect of Striking on Projectile.	Remarks (stating Temperature of Air, Muzzle Velocity and Energy).
	deg.	min.	tons					
1	30	0	15.5	2 ft. from right edge and 2 ft. from bottom	Penetration.—Displacement of plate, 13 in. by 13 in., partly drawn back; depth of indentation, ½ in. Plate driven back locally. Size of injury, 2 ft. by 1 ft. 8 in.	Plate.—Size of bulge, 13 in. by 13½ in.; height, 1½ in, Backing.—Size of indent, 17½ in. by 13½ in.; depth ⅞ in.	Projectile broken up into three large pieces and several small ones.	Temperature of mag., 59 deg.; air, 61 deg. Powder, —Mk. I E X E
2	25	0	15.4	2 ft. from left edge and 2 ft. from bottom.	Peneiration.—Size of injury, 12 in. by 12 in.; depth of point of core from face of plate, ¾ in. Plate cracked from bottom up to round 1. Scales broken off left edge of plate.	Plate.—Size of bulge, 13 in. by 13½ in.; height 1⅝ in. Backing.—Size of indent, 15½ in. by 15 in.; depth, 1¼ in.	Projectile broken up into four large pieces and several small ones.	Lot 332. Date, Jan. 8, 1895. Mk. 1950. E. 2663.
3	5	30 E	15.2	2 ft. from top and 2 ft. from left edge.	Peretration.-Diameter of displacement, 13 in. by 13 in.: plate set back locally; depth from core to face of plate, 4 in. plate cracked from right edge to injury of round 1. Slight scaling of left edge of plate. Diameter of injury, 24 in. by 15 in.	Plate.—Size of bulge, 13½ in. by 13 in.; height, 1⅛ in. Backing.—Size of indent, 13 in. by 13½ in.; depth, ¾ in.	Projectile broken up.	
4	5	20 E	15.25	2 ft. from top and 2 ft. from right edge.	Penetration.—Point of core protruding from face of plate, 1 in.; diameter of displacement, 12 in by 12 in.; size of injury, 25 in. by 12 in.; crack of round 1 further developed.	Plate.—Size of bulge, 13½ in. by 13 in.; height, 1 1/16 in. Backing.—Size of indent, 12 in. by 13 in.; depth, ¾ in.	Projectile broken up into four large pieces and several small ones.	
5	2	30 E	15.25	3 ft. from side. 4 ft. from top or bottom.	Penetration.—Diameter of injury, 14 in. by 14 in.; point of core protruding from face of plate, 1½ in. Plate cracked slightly between rounds 1 and 2, and also a circumferential crack at top of round 2.	Plate.—Size of bulge, 12 in. by 12½ in.; height, 1 3/16 in. Backing.—Size of indent, 13½ in by 14 in.; depth, ¾ in.	Projectile broken up into three large and several small ones.	

Results of Trial of Beardmore's Latest Plate. Attacked by Vickers' 6-Inch Gun.

Round.	Striking Velocity.	Striking Energy.	EFFECT.
	foot seconds	foot-tons	
1	1996	2764	Projectile completely broken up. Point left fuzed in plate. Slight scaling round point of impact, the extent of which was 20 in. horizontal measurement and 18 in. vertical measurement. No cracks.
2	1996	2764	The velocity obtained was identical with first round, and the effect on the plate was the same. The projectile was completely broken up. There were no cracks. The extent of injury by scaling was 17 in. vertical measurement. It was then decided to increase the charge, and round 3 was fired.
3	2049	2912	The effect of this round on the plate was very similar. The projectile was completely broken up, the point remaining fuzed in the plate. The extent of injury by scaling was 19 in. horizontal and 19 in vertical measurement. It was then decided to increase the charge again, and round 4 was fired.
4	2177	3280	This time there was rather more penetration, this being, as far as could be measured, about 3 in. as against 2 in. in previous round. The projectile was completely broken up again, and the point remained fuzed in the plate. The extent of injury by scaling was 22 in. horizontal and 15 in. vertical. There were no cracks. After round 4 was fired, it was decided to fire with a considerably increased velocity to try and ascertain the limits of resistance of the plate.
5	2261	3550	This round completely perforated the plate, but the projectile, after perforation, had apparently lost all its energy, as although it just broke the skin-plate at the back, it failed to pass through it, and the whole of the front part of the projectile could be seen lying between the skin-plate and the wood backing. The extent of injury by scaling was measured as 22½ in. vertical and 16 in. horizontal. After this round, surface cracks were found on the plate extending from the point of impact of round 1 to that of round 2. Also another from point of impact of round 1 to the top of the plate—one going approximately to the center of the plate, and the other to 18 in from the left top corner. Also from round 1 to left edge of plate and from round 5 to lower edge of plate, and from round 3 to lower edge of plate; these were surface cracks.

ELECTRICITY.

A New Form of Electric Incandescent Lamp.

From *Cassier's Magazine*, March, 1902.

Speaking of new forms of electric incandescent lamps brought out in recent years, Cassier's magazine for March, 1902, says:

"One inventor, working upon quite different lines, has brought out an incandescent lamp which has shown very high efficiency. This lamp, the Cooper-Hewitt, employs mercury vapor in a suitable glass tube, or bulb, instead of a filament, through which an electric current is led into the tube by wires sealed in each end, a small quantity of mercury being placed at one end of the tube. It is, however, found that a much higher electromotive force is required to start the current through this tube than is necessary to maintain the normal operating current after it is started. On this account a special device to obtain a momentary high electromotive force is requisite. The starting may, however, be facilitated by warming the tube by means of a Bunsen burner, by employing a vapour of the sulphide of mercury, or in other ways. Tests of one of these lamps, a tube 54 inches long by 1½ inches in diameter, showed it to have a mean efficiency of obout 0.55 watts per candle-powet, which is equal to about 85 16-candle-power lamps per horse-power. When the current is passing through the tube, the vapour glows with an intensely bright light, which, however, unfortunately, is very poor in red rays, and hence everything red exposed to it,—the lips, the ears, the cheeks—takes on a blue-black colour. The result of this is that a gastly, if not ghostly, effect is produced in a crowded room or hall lighted by these tubes. This effect is removed by the presence of a number of ordinary incandescent electric lights which supply the essential red rays. The inventor, it is understood, is at work upon this feature of the light, and will, doubtless, remedy it. He has already ascertained that a mixture of mercury vapor and nitrogen produces a rich, soft light. The light emitted by the mercury vapor lamp is evidently quite rich in actinic rays, as excellent photographs have been taken with it with an exposure of but a few seconds; indeed, the light appears to resemble daylight in this respect."

MISCELLANEOUS.

Jan Szczepanik's Bullet and Dagger-proof Waistcoat.

From *Scientific American Supplement, No. 1363*, February 15, 1902.

The long series of attempts upon the lives of monarchs and presidents of republics constitutes one of the saddest and most touching chapters of the history of our era. There certainly is no dearth of safeguards for their frustration, but in the face of the sagacity and boldness of some fanatics, who are ready to sacrifice their lives, all precautionary measures have proved inadequate. The various attempts to protect the endangered persons, at least against attacks from close quarters, by bullet or dagger-proof coats of mail, have heretofore given only unsatisfactory results. The "Panzer" of the ingenious Polish inventor now solves the problem, at least inasmuch as it insures against bullet wounds and stabs the parts immediately covered by it. Strange to say, it is not made of metal, but of silk. It resembles a sleeveless *gilet*, closed in the front and reaching from the waist to the neck. The front is formed by a single layer of the protective fabric, which, by the way, has about the thickness of the material of a winter overcoat, while the back resembles exactly that of an ordinary waistcoat. The "garment" is closed at one side by means of hooks and eyes. Weighing hardly 1½ kilos, it is so thin and light that it can be worn unnoticeably and without inconvenience under the top clothes. The smooth, pale yellow fabric consists of undyed silk; its resistance to shots and stabs is owing to the elasticity and cohesion due to the peculiar connection of the threads.

The most powerful lunges directed against the breast of a man wearing the waistcoat, with a sharp dagger or a pointed file, such as was used by Luccheni in attacking Empress Elizabeth, rebound powerlessly from the texture, without leaving a mark. The wouldbe assassin would certainly not have time to lift his arm for a second thrust after the first fruitless attempt.

Highly impressive and dramatic are the firing tests upon a live person, who, in the consciousness of his invulnerability, calmly and without moving a muscle exposes his breast, protected by the wonderful silk fabric, to the otherwise death-dealing bullets. Despite his faith in the impermeable vest, it is still a somewhat unpleasant undertaking to empty at arm's length a 7-miliimeter revolver, whose projectile at the same distance pierces a thick board, at a live person. The bullets rebound from the vest like hailstones from iron armor and drop to the ground with the point flattened.

BOOK REVIEWS.

Slide Rule Notes. By Lieut. Colonel H. C. Dunlop, R. F. A., Professor of Artillery at the Ordnance College; and C. S. Jackson, M. A. (Barrister at Law), Instructor in Mathematics, R. M. Academy, Late Scholar of Trinity College, Cambridge. London: Simpkin, Marshall, Hamilton, Kent & Co. 1901.

A most original presentation of a subject of great importence to the artillery, and at the same time a work that will certainly prove of general use to beginners taking up the subject of slide-rules. The work has been written with special reference to the British Service Slide-rule, and has been approved as a text-book at the Royal Military Academy, but as the principals involved in all slide-rules comes into play very constantly in artillery work, these notes will of general use in the subject and are of especial interest to the artillery.

The matter is set forth in simple mathematical form and is so complete that little, if any, reference to other works will be necessary.

At the beginning we have here the fundamental principles of logarithms, and the construction of a logarithmic scale, from which the slide-rule is constructed; then follows the description and the various uses of the service slide-rule and trigonametrical scales, with the method of plotting curves from equations. To all this are appended a large number of examples, and the whole is illustrated by forty-one figures.

It is an excellent production by men familiar with the subject, and at the same time *practical*. Colonel Dunlop is already well-known in connection with the automatic sight (which he has done much to perfect) and with other work in which the artillery has an interest. J. P. W.

Around the Pan, with Uncle Hank his Trip through the Pan-American Exposition by Thomas Fleming. New York: The Nut Shell Pub. Co.

This breezy booklet, "dedicated to the Spirit of Pan-America in a Spirit of Fun" will appeal to all who appreciate the fact "that men are merriest when they are from home" (Shakespeare), and those who experienced last summer in Buffalo that "their thoughts were fond and vain in the Midway" (Milton).

It is full of fun from beginning to end, and illustrated on every page with pictures that recall the scenes enacted in a manner that pleases the eye and delights the heart, and constitutes a pleasant souvenir of happy days.

J. P. W.

NOTES FROM EXCHANGES.

Possibilities of Electrical Power Transmission when one realizes that it is possible to-day to transmit with a fair efficiency from a single station over a territory of 200,000 square miles area, or, to put it in another way, over a diameter of 500 miles extent, and realizes that only six such stations would be required to serve the entire country from the Atlantic to the Pacific Ocean throughout a belt of 500 miles wide, one may well think that the alternating-current system has approached the limits of its serviceable expansion. *William Stanley, in the Electrlal Reuiew.*

The Popular Science Monthly for March opens with an article on the palm trees of Brazil by Professor John C. Branner, vice-president of Stanford University, an elaborately illustrated account of a topic of considerable economic and scientific interest, regarding which Professor Branner is especially qualified to write, owing to his long residence in Brazil; Dr. A. F. Chamberlain, of Clark University, discusses work and rest in their relation to genius and stupidity; Dr. E. P. Oberholzer contributes an illustrated article on Franklins Philosophical Society, the oldest and, historically, the most important of our scientific societies; Professor W. G. Sumner, of Yale University, gives an account of an epidemic of suicidal fanaticism in Russia; Professor L. M. Keasbey. of Bryn Mawr College, discusses the way in which the human species became differentiated into special races; Professor E. B. Titchener, of Cornell University, considers the question as to whether early movements of the body are due to volition or are independent of it; Dr. W. H. Dall, of the Smithsonian Institution, contributes a sketch of the late Alpheus Hyatt, illustrated with a portrait. The first official publication is given of the trust deed establishing the Carnegie Institution, and the scope of the institution and the relative position of science in the United States and abroad are discussed in several editorial articles. The number also contains a sketch of the progress of science in 1901.

Army and Navy Register. A Statement to the Army. On account of the great demand throughout the Army and Navy for an illustrated service paper, the Army and Navy Register, beginning with the first issue in February and following with the first issue in each month hereafter will print a handsomely illustrated eight-page supplement to its regular edition.

It is the policy of the management to have this illustrated supplement a work of art, with half-tone and press work of the best quality that can be obtained.

Since Messrs. Ridenour and Jenks, the present management, assumed control of the paper, it has been their constant endeavor to meet the demands of the service.

Cassier's Magazine of illustrated engineering has the following articles in its April number:

Electricity in Greece. The Development of Light and Power Stations and Electric Tramways. With fifteen illustrations. By Frank W. Jackson.

Municipal Trading in America. As Opposed to Individual Effort and Private Capital. By Hon. Robert P. Porter.

Electrical Energy Direct from Coal. The Probable Commercial Solution of the Problem. With eight illustrations. By J. Wright.

Battleships of the United States Navy. With fourteen illustrations. By Naval Constructor H. G. Gillmor, U. S. N.

The Work of the Engineer. Its Service to Material Civilization. By James Mansergh, M. Inst. C. E.

Electric Storage Batteries. Various Types and Their Principles of Operation. With seven illustrations. By Arvid Reuterdahl, Sc. B., A. M.

Waste Heat Engines. Results of Recent Binary Engine Trials. Illustraded. By George H. Barrus.

Healthfulness of Gas Lighting. By Edward A. Harman, M. Inst. C. F.

Education of the Machine Trades. By S. M. Vauclain.

Current Topics.—Burning Pulverized Coal.—Marconi's Wireless Telegraphy and the Cable Companies.—Wireless Telegraph Training Schools.—Objections to Limitation to the Eight-Hour Day.—The Conflict Between Gas and Electric Lighting Interests.—Charges for Electric Light and High-Efficiency Lamps.—Sawdust Briquettes as Fuel.—Stealing Copper Wire from High-Tension Electric Circuits.—New Vessels for the United States Navy.—A Fuel Oil Pipe System for City Service.—How Money is Lost Through Lack of Standardisation in Great Britain.—Fire Danger from Electric Incandescent Lamps and Flexible Cords.—Interrupting High-Potential Circuits.

The World's Work for April contains: The question, "Who is Nixon?" the man who has suddenly sprung into national importance politically, in becoming leader of Tammany Hall, in New York, is answered by Franklin Matthews, one of the most searching of the writers about Tammany in many campaigns. Apropos of the Ship Subsidy Bill, Arthur Goodrich's finely illustrated article on the Expansion of American Shipyards describes recent developments in our ship-building. The reasons for the new supremacy of Iowa in political circles at Washington are detailed concisely by Rollin Lynde Hartt, and the work of the United States in Cuba since the Spanish-American war—particularly interesting at this time—is reviewed by Charles E. Phelps, clerk to the Senate Committee on Relations with Cuba. Dealing with new conditions that are presenting themselves in international affairs are Julian Ralph's article on China and Europe Face to Face, and Oscar King Davis's outline of the results of the Pan-American Congress. The second of Prof. Robert T. Hill's articles on the Great American Desert—this time of the progress that has transformed the arid plains into great resources of wealth—is illustrated with many pages of striking pictures. Henry D. Sedgwick Jr.'s review of Tolstoy—the man and his thought—is a striking contribution to the literature about the great Russian. Many shorter articles touch upon recent developments in social, scientific, and political life, and the personalities that are back of them; the Y. M. C. A. clubs for railroad men, by M. G. Cunniff; a Chinese Newspaper published in America, by Morrison Pixley and an illustrated description of the new photographs of a lightning flash, by Philip T. Fiske. Among the full-page portraits which are always a feature of *The World's Work*, are pictures of Senator Allison, Robert C. Ogden, Wm. H. Baldwin, Jr., George G. Williams, Hugh H. Hanna, and Mr. Croker and Mr. Nixon.

The contents of **The Popular Science Monthly** for April, apart from notes and reviews are as follows:

Is this a Degenerate Age? by Professor J. J. Stevenson; The Formation and Motions of Clouds, by Professor Frank H. Bigelow; Contributions to Biology from Investigations on the Breeding Salmon, by Dr. Yandell Henderson; What is Philosophy? by Professor Frank Thilly; A Study of Calms, by Professor Edwin Grant Dexter; Our Foreign Commerce, by Frederic Emory; The Soil as an Economic and Social Factor, by Frank K. Cameron; The Draining of the Zuider Sea, by Professor J. H. Gore; The Evolution of Fishes, by President David Starr Jordan.

BOOK NOTICES.

[These books will be fully *reviewed* as space becomes available.]

The Tactics of Coast Defense, by Major John P. Wisser, Artillery Corps. A series of lectures delivered before the Naval War College (Newport, R. I.), and at Cornell University (Ithaca, N. Y.), supplemented by additional matter derived from the latest Naval and Military Operations. The work comprises the tactical principles involved in the fortification of coasts, and the battle tactics of their defence against blockade, bombardment and attack by sea.

The Duty of Troops During Public Disorder Viewed from its Legal and Tactical Aspect, by an officer of the U. S. army. Embracing a consideration of the necessity and authority for the use of troops; orders for the movement of troops and instructions as to the nature of the duties required of them; the equipment of troops, their tranportation an their subsistence en route; their conduct upon arrival at the vicinity of the place of duty; disposition of detachments and patrols for the protection of property or suppression of disorder; movement of troops through cities, selection and occupation of important points, means of communication and system of intelligence; quartering, subsistence, sanitary arrangements, and routine of duty.

Company Commander's Manual of Army Regulations, by Lieutenant William H. Waldron, 29th Intantrv, U. S. A. This book is a compilation of the paragraphs of the Army Regulations that pertain to the administration of the company's troops and battery, from the revised Regulations of 1901; also the difiest of opinions of the Judge Advocate General of the Army; of the revised statutes of the United States bearing upon the same matter, with copious foot notes to paragraphs showing returns and reports, the number of the blanks, et cetera, rexuired from the company eommanders. Price, Blue Cloth, 75 cents.

A Manual of Fire Tactics, by an Officer of the U. S. Army. Embrocing modifications and developments due to modern high power, small caliber rifles, firing smokeless powder and using a magazine, with deductions from the results of the most recent wars bearing on fire discipline, individual skill with the rifle, skill of officers in collective firing, and practical instruction in field firing.

Trumpeters' Hand Book and Instructor, by William S. Littleton, Chief Musician, 4th U. S. Cavalry. Published by authority of the Secreiary of War, Adjutants General's office, May 9th, 1901. This work is designed to secure uniformity throughout the Army in the sounding of trumpet calls and the ensemble playing of trumpet corps; to be a means of saving instructions for those trumpeters who cannot avail themselves of the services of a teacher; to enable trumpeters assembling from remote parts to play together effectively and at once. Price, Tan Leatner, $1.00.

Hand-Book of the U. S. Army, by two Officers of the U. S. Army. A short account of the U. S. Army embracing conditions of service, Organization, Uniforms, Armament, Equipment, Food and Forage, Regulations, Marches, Camps, Drill Regulations, Distribution.

A compilation of information on the above subjects from official sources in compact and readily available form and corrected up-to-date.

Care of Soldiers in Peace of War, from a Medical Officer's standpoint, by Major W. B. Bannister, Surgeon U. S. A. For use of Officers of the line. Presenting a technical subject devoid of technical language and treated in a practical and interesting manner.

INDEX TO CURRENT ARTILLERY LITERATURE.

[For Abbreviations used in Index see first number of each *volume*.]

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Reorganization of the Spanish Navy.—**R. G. de Marina**, January.

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International Red Cross and their activity in South Africa and China Wars.—**Int. Revue, Beiheft**, 26.

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Recruitment in Argentine Republic.—**Int. Revue**, December.

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The formation of two provisional cavalry regiments in Great Britain.—**Int. Revue**, January.

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Brief historical sketch as to the origin of the General Staff up to the time of Napolean I.—**Rus. Vog. Sbo.**, January.

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Contrasts in the conditions of warfare at the beginning of the nineteenth and twentieth centuries and some deductions as to possible tactical formations for the future.—**Proceedings R. A. I.**, November December.

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A comparison of recent Battleship designs.—**Eng.**, January 3.

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A Turbine Torpedo Boat Destroyer.—**Mar. Rev.**, February 27.

Eleciric appliances in ship-building yards. **Eng. Mag.**, March.

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Injuries to the eye caused by intense light.—**Scien. Amer.**, Supplement, February 15.

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Ship Canal across American Isthmus.—**Scien. Amer.**, December 21, 1901.

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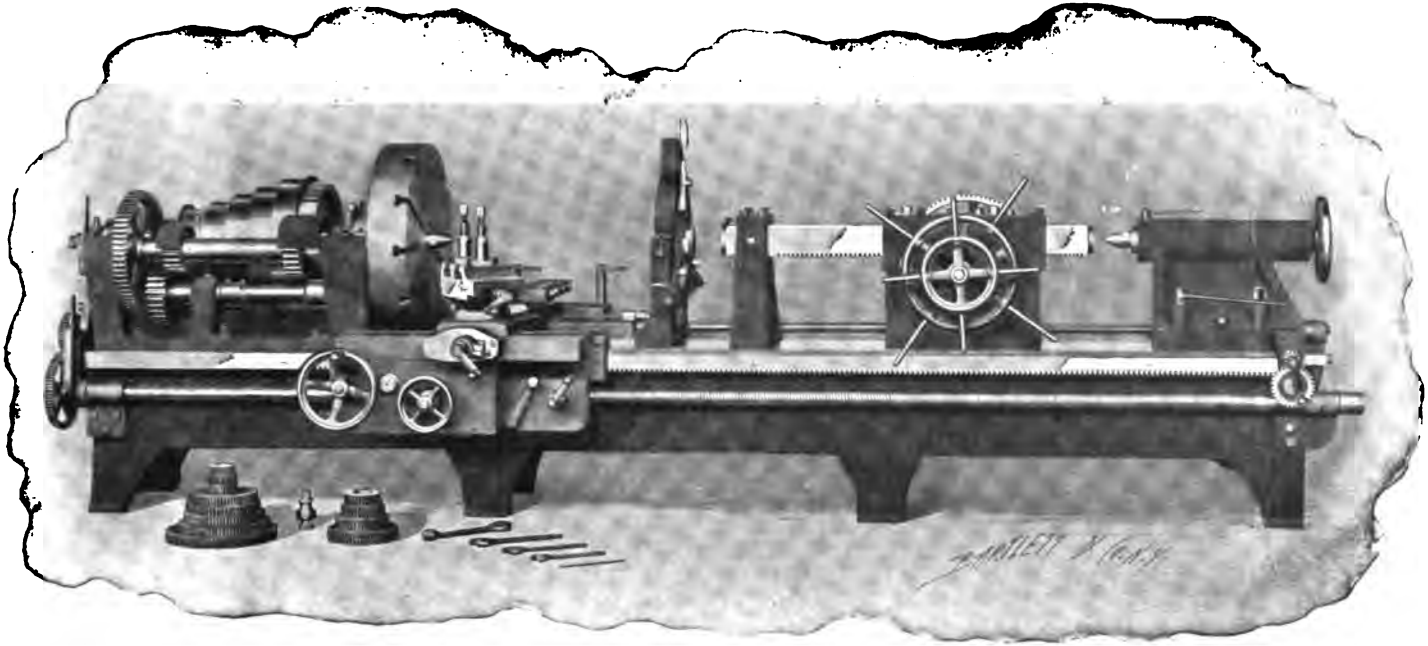

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THE ORGANIZATION, CARE AND SERVICE OF A 16-MORTAR BATTERY.

By Captain E. W. HUBBARD, Artillery Corps.

When a battery is first turned over to the Artillery there still remain numerous details to be fixed and a great deal of hard work to be done before it can be said to be fairly ready for service. The range finder must be installed and tested, gun indices set, difference charts calculated and prepared, and so on through a long list. This work is of such importance that it is practically impossible, especially with a mortar battery, to serve the pieces in action until it is done.

The following remarks, while made with special reference to a mortar battery, embody a number of features, the result of experience, and which are applicable to any kind of coast battery. The mortar battery, however, from the greater number of pieces and inherent difficulties of service demands even a higher degree of organization and drill than the H. P. battery. The highest efficiency of which the mortar is capable cannot otherwise be attained.

ORGANIZATION.

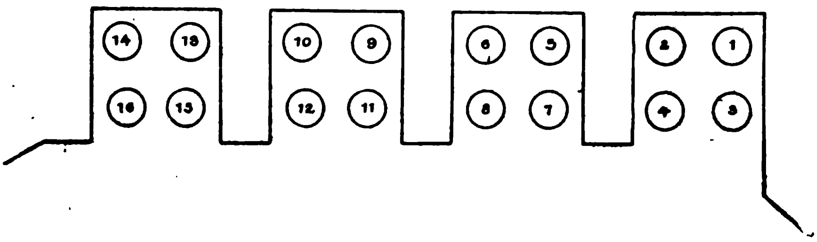
The following methods for a mortar battery are based on the principle of making each pit of four pieces a separate unit and independently organized for care, drill and service.

Divide the company into four detatchments, having as nearly as possible an equal number of non-commissioned officers, and assign to the pits in order. The 1st sergeant, Q. M. sergeant, musicians, mechanics, details for range finder, telephone, etc., report direct to the captain. Care should be taken to distribute the extra duty men so that each pit has about the same number of non-commissioned officers and men ordinarily for duty. This division corresponds as nearly as possible to the ordinary squads in barracks. This division is then preserved in all work at the guns, whether drill, care or police, and always having the same men at the same pieces results in a much higher degree of care and all round efficiency than by any system of details. While in some cases this method requires more men to do a certain amount of work than the detail system would, still as regards the general instruction of the company there is no comparison.

Each sergeant in charge of a pit is held responsible at all times for its perfect condition as regards care and police, and to a certain degree as to proficiency in drill and other matters. This creates a sense of responsibility in the non-commissioned officers and by relieving the officer of many small details permits him to arrange the more important matters pertaining to the fighting of the battery. With a raw company nothing can take the place of a minute supervision by the officers over the smallest details, even to the cleaning of a gear or the tightening of a nut. But once these matters are thoroughly instilled in the men's minds and they have been practically taught the correct way of doing things, then give the non-commissioned officer his men and hold him to accountability for results.

Divide the implements, tools, trucks, projectiles, etc., equally among the pits. Number the pits from 1 to 4 from right to left if a line battery. Each implement, truck, etc., is then stenciled with its proper pit number in white. Stencil or paint the pit number conspicuously at about five feet high on the front wall and also over the entrance to its proper gallery or traverse.

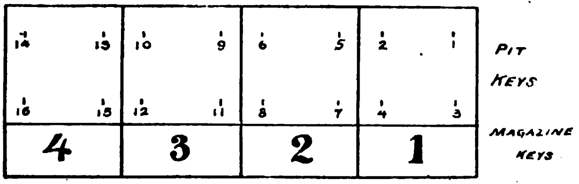
Number the pieces from 1 to 16 and stencil the numbers in white lead on the face of the breech and also on some part of the carriage, as for example the front and rear of the pedestal. In this way the piece number is always visible in any position as to azimuth and elevation. The numbers should run as the detachments would naturally stand behind the pits in double line when all the pits are manned. These numbers are the tactical numbers of the pieces and are recorded as described below, the factory numbers being never used except in reports, etc.



All spare parts, surplus oils, cosmic, etc., are now placed in the store-room and arranged in an orderly manner under charge of the Q. M. sergeant and mechanics. They issue directly to the pits as required. Stores are drawn quarterly from the ordnance officer and placed in the store-room. The Q. M. sergeant also attends to the memorandum receipts and the mechanic under him has the keys of the armament chests, etc. They precede the company, open the battery and at least once a month verify the property.

Place a bulletin board conveniently near the entrance to the battery, to contain manning tables, traversing tables, standing instructions, etc.

It is well to so arrange matters that one key, kept at the company office will open the entire battery. The magazine keys must be under charge of an officer. This may be effected by having a key-closet of design shown.



Each upper compartment has hooks for the keys of that pit. The compartments below contain the magazine keys and are all closed by one door to which the officer has the key. The key to the closet is then kept in the company office. When the battery is closed for the day the Q. M. sergeant sees, before locking the closet, that all the pegs are filled.

RECORDS.

Whe companies change from one post to another the ordinary company records go with them and this often leaves the incoming organizations without essential information as to the battery and guns. These "battery" records should give full information as to the battery, while each gun should have its own individual record. Three blank books are required as follows:

1. Book containing full range tables adapted to height of guns etc., and for different charges. One part of this book is devoted to all information needed at the range finder such as azimuths, distances, etc. Also, in tabular form, the tactical numbers of the pieces followed by the factory and carriage number and model.

2. Ordinary legal-cap blank book in which are entered all letters sent or received and which pertain solely to the armament

or emplacement; also all War Department, or other orders in force, as to care and service.

3. A book having a patent index numbered from 1 to 16 corresponding to the tactical numbers of the pieces. In this book is entered at inspections or other times, under the proper number, any defects noted in gun carriage or equipment, with a note giving action taken, when and just what repairs or alterations were effected etc. It thus becomes a running history of each piece.

At present, all such records except such as are in the Fort Record Book, go away with departing organizations and are not available. They should be properly a part of the battery records, *kept always at the emplacement* and at once available. The records referred to are very simple and should be kept by an officer.*

In the Post Record of Firing the entries *should be by battery and piece* and not by name of organization firing. At present it is sometimes very hard to trace the number of fires of a particular piece.

CARE.

Upon taking over a battery make a minute inspection and at once report all observed defects or deficiencies.

In mounting the Model 1896 carriage (Gordon's), paint the top, bottom and back of cross-head, the buffer plates and the part of the saddle behind the guides. Once mounted these parts are not accessible and rust badly and the buffer pads soon become brittle and useless. Instructions for mounting require the rollers and paths to be slushed with cosmic. This is objectionable as it collects too much dirt. Simple oiling is all that is needed as the weight spreads the oil in a film and effectually prevents rusting while the rollers are much more easily cleaned.

If room will allow, pile the projectiles in single rows on R. R. iron with points to the wall and bases outward so that they are exposed for easy inspection and fusing. If the galleries are wet the alkali quickly softens and corrodes the paint; in such case it is preferable to paint only the point, polish the bourrelet and slush the bodies with plain cosmic. They will require occasional rolling and slushing.

Unfortunately, the instructions for painting projectiles do not give any indication as to whether they are filled or not. Too much care cannot be taken in this connection to see that every filled projectile is plainly so marked and that when unfilled the marking is erased or painted over. The kind of explosive for filling could be indicated by painting the narrow portion of the body in rear of the band the appropriate color, leaving the base black. Then when the shell is filled paint the base the proper color. As the base is a plane surface it is easily scraped for the necessary changes and no doubt need ever arise as to whether a shell is filled or not. The base should be painted the moment the shell is filled. With the improved shot tongs there is no need of the colored band at the center which is placed so as to indicate the center of gravity, and it is a diffcult matter to paint this band uniformly. To paint the points, cut out of a board a circle of the diameter of the shell at the middle of the head. Bevel to fit and place over the projectile. Carry a flat brush around. This marks the line and the rest is an easy matter and uniformity in a lot of projectiles is assured.

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* Since writing the above the War Department has prescribed a system of records covering the above points. E. W. H.

Pile the projectiles according to weights and kinds and hang over each row a stenciled sign giving the information.

If projectiles are painted, care must be taken that successive coats of paint do not enlarge the body too much. This would require scraping, and where there are hundreds of projectiles to be taken care of slushing is to be preferred.

Oiling the carriages is done by the mechanics, such parts as have more wear to be oiled once a week and the rest once a month, reports being made at inspections. The pintle surface should be carefully oiled and, if necessary, holes bored to allow of its being done.

Where the cover-plates have lifting rings, cut them out, fill flush with neat cement and bore ½ inch holes for lifting.

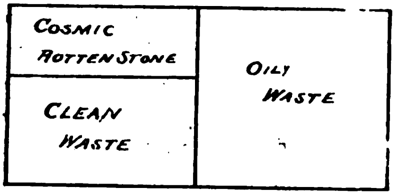
Bore hole in bottom of pedestal casing, under worm, to allow the water to run out and thus prevent rusting of the shaft.

Each pit is to have a hand box properly divided to contain rotten stone for cleaning brass parts.

Emery should be used very sparingly, if at all, and never on any part of the breech block except by direct orders of an officer. Rust should never be allowed to form, but if it does, as in a continued rain, it can be readily removed with an oily rag if taken in time. There are many places where emery paper would do no harm, but it is so liable to abuse, that constant care is required to prevent the piece being really injured. Have all supplies of emery cloth put in the store-room under lock and key, to be issued only when absolutely necessary and then only by orders of a non-commissioned officer commanding a pit.

When there is no sand or dust to interfere, the habitual position of the mortar is elevated, parallel to the piston rod or spring box and with breech covers left off. The latter is very liable to produce excessive sweating and rusting. Always leave translating roller in place except when cleaning. It is easily injured and its nut burred by replacing.

Each pit has a cleaning box of the design below, also shovel, pail and broom. Outside of the battery is located a box to contain refuse. This is placed where it can be cleaned up and taken away by the post police party.



Traverse all pieces 40 degrees each week at inspection. The setting thus given is kept throughout the ensuing week and when the battery is closed for the day the ranking sergeant must see that all pieces are alike as to elevation and azimuth. The following scheme is posted on the bulletin board:

January 1	0
January 8	40
January 15	80
	etc., to 320
	5
	45
	85 etc.

and when around the circle again start at 10, 50 etc., advancing 5 degrees each time around. This will practically give in a year all of the five degree settings and at the same time give sufficient motion weekly.

Azimuth circles are to be polished sparingly if at all, owing to liability of erasing the numbers.

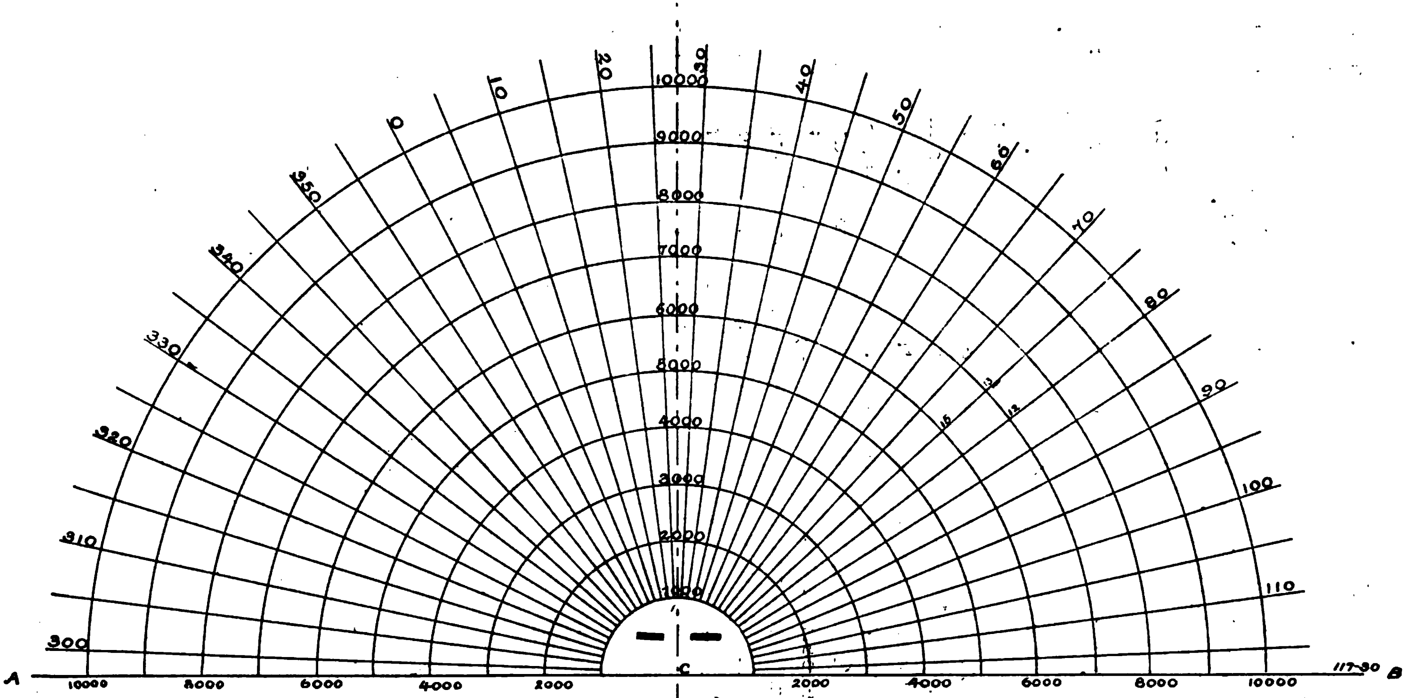
All policing about the battery, such as cutting grass, cleaning out main drains, and which would not fall naturally under the pit division, is done by details under the Q. M. sergeant.

SERVICE.

In drilling use either alternate pits or vary the pieces in each pit so as to equalize the wear on the gears. It is well frequently to drill with four full detachments in one pit so as to teach the men to avoid confusion and also the proper loading positions when the four pieces are loaded simultaneously.

Before firing be careful to see that all doors are opened, and ventilator tops removed.

Assuming that the range finder gives the corrected range and azimuth from the directing point, use is made of difference charts one for each pit, of the form shown.



PIT 1

C = DIRECTING POINT
(AT CENTER OF BATTERY)

AB = LINE JOINING DIRECTING POINT
AND CENTER OF PIT

NOTE — FOR ALL TARGETS IN FRONT OF LINE AB
AZIMUTH DIFFERENCES NEGATIVE.

WRITE CALCULATED DIFFERENCES
AT INTERSECTIONS OF RANGE CIRCLES
AND AZIMUTH LINES AS INDICATED.

DISTANCE BETWEEN RANGE CIRCLES
IS ASSUMED ARBITRARILY.

These give azimuths from centers of.pits. Range differences can generally be neglected. To construct the chart, compute azimuth differences for the centers of the pits for each five degrees and for each five hundred yards of range. Draw as shown and mount on a board. To use the chart:

The range finder reports

Azimuth 135°-15′ (includes drift.)
Range 7025

At intersection of the radial line marked 135 and range circle 7000 we find the number 13. This is in a quadrant marked plus. Adding the 13 we find the azimuth for pit 1 is 135° 28′.

This system requires no figuring and is quickly learned and applied by any intelligent man. It has been found to work well in practice. I believe it superior to any tabular form and, better than the standard difference charts with moving arm.

In the absence of any better system, visual signalling is worked as follows- The letters should be of a height and width determined by experiment so as to be easily read. They should be blue for azimuths and black for ranges and other data, all on white ground. Another set of smaller figures, is for use directly behind each pit. By telephone or otherwise the range, azimuth, pit firing, powder, elevation, etc., comes from the battery commander. The azimuth sent is from directing point and includes drift. This data is at once posted in full view of all the pits. The pit commander at once posts behind the pit the order for powder charge and shell, then applies the pit difference and posts the elevation and azimuth. Thus the confusion resulting from oral commands is avoided and each gunner has only to glance at the data, plainly before him and only a few feet away. This system should work quickly and with the smallest amount of confusion or error. What is needed is a bulletin board something on the order of those seen at important R. R. stations and which by one movement of a lever displays the time of departure of a train and the stations it stops at. Where each separate character must be selected out and placed on an easel or similar device too much time is taken up. Circular disks with windows would be an improvement, but something is wanted where, by pressing the proper key levers the characters appear instantly. It is well worthy the attention of our military inventors.

NOTE.

The selection of the proper position for the directing point is a matter of considerable importance. When, as in many cases in a line battery, the central point of the battery is selected, the result is that for the same target some pit differences are positive and some are negative. The directing point should be located on one flank of the battery and in such a position that for the principal field of fire the pit differences will all be positive.

The quadrant issued to a mortar battary should be graduated on one side only and between the safe limits for the particular carriage, or say 45 to 60. When both sides are graduated there there is considerable liability to error when about 45 degrees, and by omitting all unnecessary graduations the danger is much diminished.

The usual division of the circle into degrees and minutes has such obvious disadvantages that no argument is needed to prove the superiority of the decimal division. In H. P. guns the objections to the present system are not so obvious, but in mortar work it is a serious drawback on account of the excessive drift, which is always subtractive. Now addition is always an easier and quicker operation than subtraction.

These difficulties can then be greatly lessened by adopting for azimuth and other circles a decimal division and numbering in azimuth from south (or north) *against the hands of the watch.* This will make all drift corrections *positive.* The present mortar circle gives 3 minutes ar smallest division. The circle is thus divided into 7200 parts. Divide circle into so many hundred parts, so that one tenth of this main division will be smallest unit used in practice.

Given this case in mortar:

Azimuth	135—15
Drift	3—37
Difference	131—38

By method outlined above it would be something thus:

Azimuth	955. 7
Drift	10. 2
Sum	965. 9 = setting.

Thus time is saved and liability to error much reduced. The question of any system is not "Can it be worked accurately?" but "Can it be worked accurately and quickly under conditions obtaining in an action?"

While the range tables of Colonel Ingalls for mortars are scientifically correct, the form is such that they cannot be used practically. The graphic range tables issued by the Ordnance Department are admirable. They should be drawnto a somewhat larger scale and the divisions of the degree made uniform. Some divisions are now 10 minutes and some 15 with resulting liability to error in using.

As in all artillery firing the powder is the main uncertain element, it is precisely in this important matter that the graphic tables are far ahead of the tabular forms. In one case B. P. powder about four years old proved to be about 950 yards short at 8200. Here the firing of the previous year was depended upon to give some idea for the first shot. Ninety pounds was accordingly fired as though it was 81.

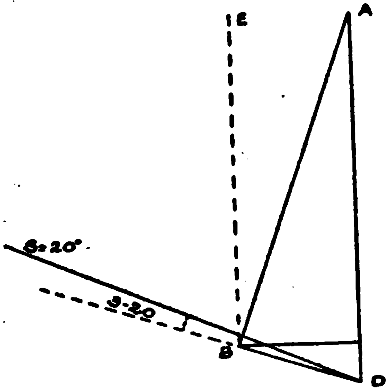
Theoretically the range of the mortar is varied by changing either the elevation or charge or both. Practically, while the elevation may be anything from 45 to 60 the number of kinds of powder and sizes of charges must be fixed as low as possible. By inspection of the graphic tables select the smallest number of charges that will cover the field of fire and allow no other sizes in the magazines. This number ought not to exceed four or five, else confusion is likely to result in service in action. Fire a shot and from the observed range draw in the powder or velocity line and mark distinctly with the weight of charge. In case of actual hostilities this should be done for each charge and each lot of powder, selecting a quiet day so as to minimize the effect of the wind.

The first shot, in the absence of preliminary firing, must be very largely a matter of judgment. One beauty of the graphic table is that after the first shot the causes of variation in range can all be included in the location of the powder line. If atmospheric conditions vary, a line for the day can be drawn in.

It would be a great advantage if the graphic tables were engraved on celluloid or slate so as to admit of erasures.

While the mortar is not well adapted to firing at moving targets and is subject to a number of causes of error from which the H. P. gun is free, still I believe that the real errors of the mortar have been exaggerated, and that it is possible by the use of graphic tables, careful study and correct organization, to make targets comparing very favorably with these of H. P. guns, everything considered. The recent careful experimental firings at Portland Harbor may be confidently expected to furnish very important data which was formerly lacking. Thus much light can be thrown on disputed points and the best method of handling mortars in action be determined. While mortars cannot be relied upon for the main defense, still as auxiliaries they are of the highest value. Certain it is that the mortar, like the torpedo and mine, will not be despised by the enemy afloat.

The following method of computing azimuth differences is by Captain S. C. Vestal, Artillery Corps.



D center of battery (directing point); B center of pit; A target.

Draw E B parallel to A D and B C perpendicular to A D.

$< BAC =$ difference of azimuth of target A from points D and B.

$$< EBA = < BAC$$

$$\sin BAC = \frac{BC}{AB} \qquad (1)$$

$$BC = BD \sin BDA \qquad (2)$$

$$\therefore \sin BAC = \frac{BD \sin BDA}{AB} \qquad (3)$$

The difference between A D and A B being small A D may be substitute for A B in equation (3).

$$\therefore \sin BAC = \frac{BD \sin BDA}{AD} \qquad (4)$$

Suppose D S (20°) be the first 5° azimuth line falling to the right of B D and that the difference of azimuth between B D and D S be 3° 20′, the values given to B D A will be 3° 20′, 8° 20′, 13° 20′, etc. The angles will have to be picked out for two quadrants only. If D S coincide with B D or if the azimuth difference be small, the angles need be picked out for but one quadrant.

The logarithm $\frac{BD}{AD}$ is of course the same for each range.

COMMENTS ON "REPORT OF COAST ARTILLERY TARGET PRACTICE, FORT MONROE."

(See January-February number of this Journal.)

This report was received on the Pacific Coast with the interest it deserved on account of its being apparently the first report made public, in which practice rather than theory was the prevailing factor that determined the application of common sense ideas and methods applicable in actual service.

It is to be regretted that the report is not more in detail, showing what account was taken by the range officers, of the atmospheric conditions in determining predictions; and where or by whom were the corrections for wind and dritt made; I assume that these were made by the gunner and to that end have constructed what I call a gunners table, containing drift, wind and time of flight for every 500 yards of range.

I find that with some practice the gunner can make these allowances with sufficient accuracy and rapidity.

It would be exceedingly interesting and instructive if the exact written orders issued by the Fire Commander previous to and preparatory for this practice could be published; it would doubtless be of great value to battery and fire commanders at stations where facilities are soon to be completed for fire direction and fire control and where this work is in charge of officers who have had practically no experience in this interesting and necessary part of instruction.

Captain Weaver has kindly furnished me with a number of copies of this report which have been placed in the hands of the non-commissioned officers of my company who show a degree of interest and understanding that could never be taught them by the study of the total theoretical and, to me, somewhat mystified treatment of the subject in Part VI of the Drill Regulations, which in this practice appears to have not been strictly followed as enjoined in G. O. No. 36 of 1901. Indeed it would in my opinion be a difficult matter to follow the provisions of Part VI of the Drill Regulations and have anything like service practice.

Major Whistler's method has been carefully studied and followed in every detail by my company for about two months with the result that my Range Officer, Lieutenant V. C. Lewis, has his detachment (permanently assigned) in what may be called "expert" condition.

I find that with such a detachment it is possible to fire the guns (10" disappearing) every three minutes with a fair degree of accuracy.

This method presupposes expert instructors and perfectly instructed men, such in fact as we can never hope to have in time of emergency, when, to man all of our guns it will become necessary to make use of either Volunteers, or increase the regular force by a very large percentage of new and uninstructed men.

I have tried Whistler's method in comparison with a method under Case II. devised by myself and my non-commissioned officers, (being then alone with my company) which is almost precisely the same as that used in the practice at Fort Monroe, and found the latter with one fourth the practice and instruction very much superior both as to accuracy and rapidity of fire. The two methods were repeatedly tried at drill at the same time at the same target but with different guns. In one case of a large steamer moving at a speed of sixteen miles per hour, by Case II. were fired five shots in eight minutes four of which were reported "hits" midship section, and one, (first shot) hit stern section.

With the gun (directing gun) using Whistler's method two shots only were fired in the same time and one hit recorded in the bow section, and one miss; the steamer passed out of range (around Point Lobos) in just ten minutes after passing through the Golden Gate. Two more steamers were tried on the same day with even more advantage for the gun using Case II. similar results were constantly reported.

For Case II. Type "B" Position Finder was used taking range every thirty seconds, and predictions and corrections for range made by two men at the gun emplacements. Corrections for deviation and movement of vessel were made by the gunner and the gun was loaded and made ready for firing with ease in less than two minutes. In both guns, in fact at all drills, full service weight projectile and dummy cartridge were used- Electric primers (fired) were inserted each time and attached to firing box. Comparison of these two methods has been made for some time with the result that no room is left for doubt that, for action, with the material on hand, as a rule in time of war Case III. has no place in firing with high power guns of 10" caliber or less, or 12" on disappearing carriages, where the target can be seen.

There is no doubt in my mind that Major Whistler's success in target practice as reported in his pamphlet was largely due to his remarkable energy and work whereby he instructed his men to such a degree as we can not hope to attain for the personnel of our forts in time of war, or for that matter in time of peace.

I have digressed here simply because our drills here on the Pacific Coast pointed to the necessity of a more practical method than had yet been outlined.

It does not appear quite clear how the record in the practice at Fort Monroe was made. Page 122 Drill Regulations under Service Practice, Fire Command, it says "The record should be made independently of, and, as far as practicable, without interfering with, the the work of the Fire Command". Such is evidently the intention under General Order No. 36, of 1901. On page 6 in Captain Weaver's report he states "For this purpose (taking deviations) battery commanders arranged a tabulated form as follows", from which it would appear that battery commanders made their observations for record.

It may be that "officers commanding the practice" made these observations, but the report does not so state. It would add to clearness, to have this explained.

It is to be noted that in the practice a full complement of officers was present with each battery, a condition that we may, I think, assume will never occur in action. At this station for a period of four months we have not had more than one officer for each company and these as a rule, without experience. This condition is, of course, unusual and easily accouted for, but in time of war many officers are always required for important work that will take them away from their stations, and it seems to me that non-commissioned officers should be trained to take all the duties of the range officer as well as the battery officer.

"Importance of specialists in personnel", discussed on page 14 of the report, certainly is a very important consideration, but it seems to me at least improbable that such a radical change as here advocated would be wise to attempt at our present stage of development under a new system and organization.

The company as now constituted by law can be varied in its strength by orders and doubtless that was intended when the law was framed.

I have no doubt that companies will in time be regulated in numbers both as to officers and men according to requirements, much as is now the case in the assignment of officers and men to men of war.

It would seem to me best to be sure what may be developed into the best fighting unit and when that is satisfactorily established advocate the unit of Administration to be the same. In making the Fire Command as it is now understood, the unit of Administration, might lead to errors perhaps as serious as the present order fixing 109 as the strength of each company.

On page 15, the report continues "As matters now stand the companies are assigned to the service of certain guns and the other divisions are provided for by details. The men so detailed look upon the work as a side matter and this is shared to some extent by their officers."

I think this statement deserves serious consideration; companies at this station are assigned to Batteries, or perhaps better, Batteries are assigned to Companies; by battery is meant everything everything relating thereto including position finder, communications, electric plant for lighting, care of police area, in fact everything that is connected in any way with the battery.

On page 111 of the Drill Regulations under "Drill" is found the following: "The drills for the various guns of the armament will be based up on the following considerations. . . . Permanent details for the position finder and communications." On page 124 Drill Regulations we find the following: "In Coast Artillery a battery of heavy guns, without a range finding instrument is not contemplated."

It would seem that in this latter respect Fort Monroe is somewhat behind other stations in that it appears to have but one position finder, and that may have led to a detail system.

The range and communication detachments in this fire command are permanently assigned, in fact they consist of selected men.

The service at the guns would appear to be admitted as the simplest part, since on page 14 the report states "(This we may be said to have)" implying that "Communication service, Position Finder service, and Power and Light service, we may not be said to have;" I think my company may be said to have them all except Power and Light service in which specially selected men are now being instructed. These details are of a permanent and important nature and officers who look upon them as "a side matter" do not appear to me to have a proper appreciation of some of the most important duties that must be combined to make the instruction of a company complete.

I might add that men would have been instructed before this in the use of the electric plant had it not been that electrician sergeants were detailed for this purpose. The principal work done by them that became prominent was to hide the keys so that the battery commander could not get an opportunity to instruct himself and his men in the use of the plant.

Each gun in the battery with its emplacement, implements, stores, police tools, slopes and police area, is permanently assigned to a gun commander as contemplated on page 75 Drill Regulations.

On page 112 Drill Regulations we find the following: Assignment at the guns and position finder will be permanent, the object being to have each man thorough in a definite duty;" and on page 114 concerning communications, "such important part is played by communications that no pains should be spared in keeping them in perfect order etc."

If under such instructions an officer considers everything but gun service "as a side matter" I am afraid he has missed his calling.

Evidently both by the Author of this report and by the Drill Regulations they are considered as the most difficult and most important duties for efficient service in action.

Taking this view of the company, i. e. as the personnel of a battery which must always be the "unit of instruction" it does not seem to me that it is necessary to take quite so sad a view of the matter as is taken on page 15 of the report, which continues. "If a high standard is to be attained in the new service, we must have torpedo companies etc."

I am ready to advocate a change that will make the fighting unit the unit of administration, but it is evident that the former should be thoroughly agreed upon first, for if that should be changed we would have the same condition again that we have now, i. e. the administration unit different from the fighting unit.

I believe that many of our most experienced officers hold the opinion that in any serious engagement, however well fire control may be established, the combat would soon get to the stage where it would have to be carried on exclusively by battery commanders; it might be well therefore to consider carefully before taking away from his control the important duties of Position finding and communications relating directly to his battery.

The fighting unit in my opinion should also be the unit of instruction, and to make the unit of instruction the Fire Command, might develop serious disadvantages in too much concentration of command which would be unwieldly and necessarily slow of action.

Rapidity of fire is getting more and more important as the speed of vessels and their rapidity of fire increases, so that in any system every precaution must be taken to avoid interfering with the fullest development of fire of any or all the batteries.

In a fire command like that at the Presidio with six heavy high power batteries, one Dynamite Battery, two Mortar Batteries and five Rapid Fire Batteries, it would certainly tax the Fire Commander severely to control all these personally, and if he can not control them personally, they would have to be controlled by staff officers, not as experienced ordinarily as Battery Commanders.

Would it not under these circumstances be better to give, previous to the battle (or better previous to war) general instructions to Battery Commanders that would act as a guide to them in action, and leave them unhampered in the development of the fire of batteries to the fullest extent, reserving for the Fire Commander only a general supervision.

This appears to be all that one officer can hope to do with a large fire command.

Under "General Results", page 3 and 4, the report states "that a time limit of five minutes only was permitted between the order of the fire commander to fire and the discharge of the gun or salvo, and that the personnel of the Fire Control Communications was uninstructed in the duties of the telephone service.

These are, apparently given as excuses for poor results. Were the guns discharged as required within the five minute limit? If not so discharged, were the shots lost to the company firing?

There does not appear to be any excuse to have Fire Control Practice before first properly instructing the personnel of the Fire Control Communications. This should have been attended to by the Fire Commander or his staff officer before the practice was ordered and does not seem to be a legitimate excuse for unsatisfactory results.

The results attained in this practice under the conditions appear to me to be very encouraging and on excuses need be offered for unsatisfactory results, which appear to me to be very satisfactory, and any criticism of the methods here made is only with a view to getting a better understanding to the end that such parts of the practice as proved satisfactory, may be taken advantage of, and made useful in developing systems of Fire Direction and Fire control at stations where this has not been practicable heretofore.

In carefully reading over the report the folowing questions suggest themselves:

1. What was the condition of the weather at the time of Practice, Thermometer, Barometer, Wind, etc.?

2. What corrections were made for these conditions?

3. What was the total time elapsed during the practice?

4. Was the practice unavoidably interrupted? if so, how and how long.

5. How many men were used away from the guns?

6. How many guns were manned?

7. How many shots were fired in the five minute firing at will by the batteries?

(Note—It would seem that 25 rounds were fired by order of the Fire Commander exclusively of the "fire at will" for five minutes, leaving only 4 rounds for the seven guns for five minutes fire at will by all the batteries.)

8. Were any shots lost on time limit? if so, how many?

9. Were Battery Commanders required to make any record themselves or by their details other than would be required in action?

10. What was the direction of movement of the target with respect to the line of fire?

11. (Page 9 report "Prediction") How could the range officer make a prediction "as soon as the position of the target, as given by one set of azimuth and range, was plotted", unless he assumed to know the speed and direction of the moving target?

12. Who made corrections for drift and wind?

13. Is there any hope of having location of Battery Commanders stations that are now in undesirable and distant points, changed.

14. Why did the board that located Battery Commanders stations make these generally coincident with the Position Finder stations, in some cases more than a thousand yards from the guns? (10" Dis. Battery. Presidio.)

15. Did the blast of the guns interfere materially with telephones placed near them?

16. Why does not the Signal Corps furnish communications that can be placed underground?

17. Does any one find any objection to the sight proposed by Captain Weaver? If not it should be adopted at once; such a change would be welcome.

18. Did all disappearing guns recoil to the loading position each time?

10. Is Whistler correct in saying (see his pamphlet page 13) "The use of several telephones, bridged on the same circuit, is an absolute failure"?

W. G. Haan,
Captain, Artillery Corps.

* * *

NOTE.

ANSWERS TO CAPTAIN HAAN'S INQUIRIES.

Captain Haan makes a number of inquiries which will be answered in so far as possible.

Q. "What account was taken by range officers of the atmospheric conditions in determining predictions?"

A. None in determining predictions. In some cases complete corrections were made by battery commanders, or at least an attempt was made to make these corrections as prescribed in the drill regulations and as entered in the battery commander tables, but there was too much delay in the process. The powder was so variable in its pressures that no conclusions could be drawn as to range variations in any event.

Q. When and by whom were the corrections for wind and drift made?

A. Battery commanders made the corrections for wind and drift and the final correction was announced to gunners. The allowance for motion of target across the range was made by the gunner by actual trial, noting how many divisions of the scale were passed over in an interval of time equal to time of flight for the range. In some cases gunners after noting the time of flight from a range scale would count off the seconds, "1, 2, 3, 4, etc.," at the same time noting the passage of the target along the deflection scale; the scale was then set for this motion, and tested from time to time by the gunner; finally this was corrected for wind and drift from the B. C.

Q. Written orders issued by the Fire Commander previous to and preparatory to the practice?

A. Some of the orders are not now available, but those essential to the plan are given:–

SCHEME FOR TARGET PRACTICE OF A FIRE COMMAND, COMPOSED OF FOUR BATTERIES. FORT MOMROE, JULY 18, 1901.

1. Twenty-nine rounds will be fired from 10 in. B. L. R. and six from 8 in. B. L. R., using two guns in each of four separate batteries, namely:—Redoubt A, Redoubt B, Redoubt C, Place of Arms.

2. Ten rounds will be fired from Redoubts B and C, five from Redoubt A, six 8-in. and four 10-in from the Place of Arms.

3. Captains in charge of batteries designated will report before retreat this evening (July 17th) that the cyilnders of

carriages to be used have been adjusted for the charges to be used (practice with service projectile) and that the quadrant arcs have been compared carefully with the quadrant and necessary corrections noted. The reports will also cover all other points mentioned in drill regulations as necessary to be included therein.

4. The following officers will be in charge of the firing at the places named and will also take deviations of shots thereat:

Redoubt A - - -	Captain Barrette.
Redoubt B - - -	Captain Bartlett.
Redoubt C - - -	Captain Walke.
Place of Arms - -	Captain Cronkhite.

5. The B. C's. permanently in charge of the guns to be used in the firing will, on application, supply battery commander's who are assigned to the gun for the day, with range tables, plotting boards, sights and other essential means to conduct the firing.

6. Battery commander's will be permitted in so far as possible to select their gun commanders, gunners, detachments and details at the guns. These selections should be made at once and reported to the adjutant.

7. All enlisted men of each battery not specially assigned to duty will be held in reserve, together, near the guns, apart from the men at the guns, for such duty as may be given them by the officer in charge of firing at that point. These reserves will be under control of the senior non-commissioned officer of the party.

8. Battery officers, and range officers, will report to their battery commanders for instruction at the earliest opportunity and not later than retreat this evening (July 17).

9. Battery commanders will report for instructions immediately after retreat this evening.

10. Firing will begin at 2 p. m., July 18. Battery commanders will see that ammunition is in place and ready for use and personnel instructed in duties by that time.

10. The following assignments of officers of the class are made for the firing.

Captain Todd: Battery commander at Redoubt A to fire six 10-in. B. L. R. service projectiles, practice charges.

Captain Winston: Battery commander at Place of arms to fire six 8-in. B. L. R and three 10-in. B. L. R., service projectiles, practice charges.

Captain Pence: Battery commander at Redoubt C to fire ten 10-in. B. L. R. service projectiles, practice charges.

Captain Patterson: Battery commander at Redoubt B to fire ten 10-in. B. L. R. service projectiles, practice charges.

Lieutenant McIntyre: Battery officer at Redoubt A to report to Captain Todd for instructions as soon as possible.

Lieutenant Spinks: Battery officer at Place of Arms to report to Captain Winston for instruction as soon as possible.

Lieutenant Scott: Battery officer at Redoubt C to report to Captain Pence for instructions as soon as possible.

Lieutenant Brown: Battery officer at Renoubt B to report to Lieutenant Patterson for instructions as soon as possible.

Lieutenant Farrar: Range officer at Redoubt A to report to Captain Todd for instructions as soon as possible.

Lieutenant Granger: Range officer at Redoubt B to report to Lieutenant Patterson for instructions as soon as possible.

Lieutenant Frohwitter: Range officer at Redoubt C to report to Captain Pence for instructions as soon as possible.

Lieutenant Ellicott: Range officer at Place of Arms. to report to Captain Winston for instructions as soon as possible.

11. Other assignments as given in regular target practice form.

The programme of firing will consist of five series of shots, namely:

1. One round from each battery to determine powder error. Overs and shorts will be signaled from the tug for this series. Having reported "ready" to fire commander, battery commanders will be directed when to fire. Message sent, "stand ready for second series," to all battery commanders.

2. Promiscuous single-gun firing. The fire commander will order: *Redoubt.....*, *Gun No......*, *Fire on* (*such part of the target.*) As soon as the order is received the battery commander will lay and fire. After message is received "stand ready for second series" all guns should continuousty follow target and be kept elevated for current range as given by position finder,

As soon as a gun is fired it will be loaded as quickly as possible and reported "ready" to fire commander by battery commander. Gun commanders will keep a record of the loading interval from *fire* to the attaching of lanyard to primers. This record will be handed to battery commanders to be turned over to fire commanders after the firing. Defects of methods or material will be noted on the records. *This rule is general for all gun commanders and all firing.* After a battery commander is ordered to fire, time will be taken by fire commander until order is executed. This will apply to all controlled firing. When second series is finished message will be sent to battery commanders; "second series off, stand ready for third series."

3. Promiscuous salvo firing by battery. The fire commander will order: *Redoubt*........., *Fire salvo on* (*such part of target*). battery commanders will fire as soon as possible. Principles given under "2" being observed. When third series is finished message will be sent to battery commanders; "Third series off, stand ready for fourth series."

4. All batteries firing at will at mid-ship section of target for five minutes. In this series the order will be: "*All batteries fire at will, mid-ship, five minutes. Commence firing.*" Redoubt B will at once open fire. As soon as the first projectiles from Redoubt B have struck, Redoubt C will begin firing. As soon as the first projectiles from C have struck, A will begin firing. As soon as the projectiles from A have struck, the Place of Arms will begin firing.

Officers in charge of firing at each battery will keep accurate time and order "CEASE FRING, *exactly on the expiration of five minutes from the time the order to fire is given to guns by battery commanders.* guns will be reloaded, and battery commanders will report to fire commanders how many rounds are left.

5. The fifth series will depend on the amount of ammunition that is left. Special directions will be given in regard thereto by the fire commander, at the time.

Officers in charge of firing at each battery will exercise full control over all matters of safety of fire.

Under "Remarks on Firing," on the Record of Deviations, officers in charge of firing will express an opinion as to the manner in which the personnel performs its various functions including gun service, ammunition service, replotting, and general efficiency of the fire discipline. Officers in charge will select time keepers from the reserve men. Officers in charge and battery commanders should each have field glasses.

Officers acting as battery commanders, battery officers and range officers, will submit to the fire commander a report in writing, setting forth the details of that portion of the firing under their supervision, respectively, and will especially indicate defects of methods or means, and offer any suggestions that may occur to them as to how best to remedy defects.

Q. It does not appear clear how the record was made.

A. The records of deviation, time, etc., were made, not by the battery commanders, but by the officers commanding the practice.

Q. I am ready to advocate a change that will make the fighting unit the unit of administration, but it is evident that the forms should be thoroughly agreed upon first.

A. This is all that is suggersted in the Report. The proper "fighting unit" is, in my opinion, our fire command, the command of a major or lieutenant colonel. It should consist of two to four batteries, depending on the size, corresponding to the English "battery" command. Some confusion has arisen in our service due to the fact that while our Drill Regulations are taken almost bodily from the English Drill Book, their units and ours have different meanings. The English "group" corresponds to our "battery;" the English "battery" to our "fire command." The latter is thought to be the natural fighting unit. The next higher natural division in our service is the *Fort* corresponding to the English *Fire Command.*

Q. Were the guns discharged within the five minute limit after the order from fire commander to fire on target?

A. Yes, except when delayed by carriages failing to function properly in recoil, and sticking of breech blocks due to the obturator getting out of adjustment.

Q. There does not appear to be any excuse to have Fire Control Practice before first properly instructing the personnel of the fire control communications. This should have been attended to by the fire commander or his staff officer before the practice was ordered.

A. It should be kept in mind that the post of Fort Monroe with its garrison is distinct from the Artillery School and its personnel. The school depends on the fort for material and personnel in practical work of this nature. The firing was for the instruction of the class of student officers and was conducted with the means furnished by the post, including the enlisted personnel. The organization for the practice was only for that occasion. The fire commander had no control for purposes of instruction or permanent assignment to duties of the communication personnel.

Q. What was the condition of the weather at the time of the practice—thermometer, barometer, wind, etc.?

A. The weather was fair. The reading of thermometer and barometer are not at hand, but the conditions were practically normal. Wind about 5.0 miles at 6 o'clock.

Q. What corrections were made for theses conditions?

A. Battery commanders, announced to battery officers or gun commanders the corrected range and deflection for wind and drift. The first shot was based upon all conditions affecting the range, known to the battery commander. Thereafter he did the best he could with the variable powder pressures.

Q. What was the total time elapsed during the practice?

A. One hour and thirty-five minutes; from 2:42 p. m., to 4:17 p. m.

Q. Was the practice unavoidably interrupted, if so, how, and how long?

A. Certain guns were interrupted at times by carriages failing to function and breech blocks sticking, and the programme on this account was departed from slightly. If one gun was not ready to fire when ordered another was ordered at once.

Q. How many men were used away from the gun?

A. Seven men in fire commander's station; eight men on tug.

Q. How many guns were manned?

A. Four batteries of two guns each.

Q. How many shots were fired in the five minutes firing at will?

A. In addition to the 29 shots fired for instruction purposes by the school, there were 6 shots fired from the 8 in. B. L. R. by the 69th Company Coast Artillery as a part of its regular annual target practice record, making 35 shots in all.

These were fired as follows:

1st. series	5
2d. series	8
3d. series	4
4th series	11
5th series	5
6th series	2
	35

Q. Were any shots lost on time limit?

A. As already explained the firing was for purposes of instruction of officers in fire control, as a part of the school course, and was not conducted under G. O. 36. However, it may be said, that, in all cases, the guns were ready to fire when ordered, except as prevented by failure of carriages to function and breech blocks sticking.

Q. Were battery commanders required to make any record themselves or by their details, other than would be required in action?

A. No one connected with the firing was detailed to keep records. The deviation record was kept by "officers in charge of firing" at each battery. The errors of range was kept by officer on the tug. Each officer in charge of firing selected a time keeper from the reserve of the battery whose firing he supervised.

Q. What was the direction of movement of the target with respect to the line of fire.

A. The target was towed from a point near Thimble Shoals Light towards Willoughby Spit, moving in a closed loop. The rate of change in range was at times over 100 yards per minute. It was estimated that the targets could be towed with safety at angles included between 10 and 8 o'clock, and 2 and 4 o'clock. That is, the angles within which armor could be attacked.

Q. How could the range officer make a prediction "as soon as the position of the target as given by one set of azimuth and range was plotted"?

A. *The observations were taken continuously and proceeded independently of the work of the guns.* Ninety-five separate observations were taken in the course of the firing. The range officer after the first three observations was able to make a prediction for each set sent in. His predictions, for two minutes ahead, were sent to the gun every minute, and, usually, the men in the guns had the range of the target from 10 seconds to 60 seconds ahead of the "present time," and were able to fire when the gun was loaded.

Q. Who made corrections for drift and wind?

A. The battery commander. It would be better to relieve the battery commander of this, or any other computation.

Q. Is there any hope of having the location of battery commander's stations that are now in undesirable and distant points changed?

A. It is thought some of our officers have gotten the English "battery commander" confused with our "battery commander." The British battery commander's station really corresponds to our fire commander's station. The British "gun group commander" corresponds to our "battery commander" and it is to be noted that the British place the gun group commander strictly at the guns.

Q. Why did the board that located the battery commander's stations make them generally coincident with the position finder' stations in some cases more than a thousand yards from the guns, (10 in Disappearing Battery, Presidio)?

A. When such is the case the officer who occupies it is really a "battery commander," in the British sense only. He is not a "battery" commander in the sense in which we use the word "battery." The hope is earnestly shared that we may work away from such remote relations between the American Battery Commander and *his* gun "group" with its manning body and accessories.

Q. Did the blast of the guns interfere materially with telephones placed near them?

A. No.

Q. Why does not the Signal Corps furnish communications that can be placed under ground?

A. It is understood that these will be put in soon. The appropriation for the fiscal year 1902-3 has a large item for such work as this.

Q. Did all disappearing guns recoil to the loading position each time?

A. No. They did as soon as we found just how much oil and weights each carriage required, but it took a number of shots to determine this.

Q. Is Major Whistler correct in saying "the use of several telephones bridged on the same circuit is an absolute failure?

A. It is thought good results may be had with such a system. A system that could be used with telephones either in series or parallel would be desirable. Visual signal as by the telautograph is advocated for azimuth, range and deflection.

As matters of possible interest the reports handed in by battery commanders are appended. Since the firing last year a manning drill has been prepared for trial. It is given herewith by way of offering a suggestion to others who may be working along these lines, and to invite suggestions as to modifications in the interests of accuracy and rapidity, in firing at moving targets.

E. M. W.

Fort Monroe, Va., July 18, 1901.

Captain E. M. Weaver,
Artillery Corps,
Fire Commander.

SIR:

I have the honor to submit the following report of the working of the fire control practice to-day at Redoubt "B":

As a rule everything worked very smoothly. Messages were transmitted and received with a minimum of delay, and orders received from the Fire Commander were carried out promptly on every occasion except when the presence of steamers or sailing craft in the neighborhood of the line of fire made it unsafe to fire. The guns were loaded, tripped, and ready to fire in every case, the loading for every round being completed in the prescribed time. Gun commanders and gunners showed great interest in the work and performed their duties most efficiently.

The plotting and predicting was in charge of First Sergeant Neville of the 13th Company, assisted by Corporals Scott and Terry of the 35th Company. Predictions were made every minute for two minutes ahead, without missing a prediction during the entire afternoon, with an accuracy which an inspection of the plotted and predicted positions of the target, after the practice showed to be quite remarkable. Which goes to prove that this class of work is well within the capacity of our best non-commissioned officers.

Both Sergeants Egan and Safferts (13th Company) handled their detachments well. They were provided with range scales, and changed the elevation of the piece every minute to agree with the ranges as shown on a large blackboard in rear of both emplacements, together with the corresponding time. The range correction was given to each gun commander and applied by him, taking the elevation corresponding to the corrected range. It was found that the range correction for powder was 150 yards, plus.

Both gunners were very efficient, particularly Corporal Stayton (13th Company), whom I consider the best man in his position I have ever seen. Corporal Garmon, (13th Comany), did very well also, but owing to having been instructed in two different systems of setting off deflections, he became confused on the second round (first round from No. 1 gun). He set off left deflection (10′) as right deflection, throwing the shot just to the right of the front target, instead of in the stern section, where the correct setting of the sight would have brought it. This shows the necessity for uniformity in the instruction of gunners. This gunner was told what would be given him and what it meant, and understood it perfectly this morning, but in the excitement of firing he evidently set off the deflection in the way he was accustomed. I have found that a majority of gunners are instructed that "right deflection" means "fire to the right",—"carry the muzzle to the right." In all the late telescopic sights, moving the vertical cross-hair to the left will accomplish this. In *all* our sights (except the old Scott), real or apparent motion of the zero of the scale to the right will carry the muzzle to the right, or vice versa. The incident mentioned shows the responsibility resting on the non-commissioned officer acting as gunner, and suggests that it should be recognized by increased pay, and possibly increased rank, to secure the best men obtainable.

No difficulty was experienced in firing salvos. The battery commander's station, most of the time was in the traverse between the gun emplacements where both could be observed and orders transmitted to either gun equally well. This is probably the best station for the battery commander, and could probably be occupied even in time of action until a ship came within 5,000 yards. Then he could go into a conning tower built right in the traverse, so arranged that a full view of the harbor could be recured, and with good communications to the guns on either side. The surface of the traverse would be hardly as dangerous a position as the bridges of our battleships where most of their captains insist on exposing themselves. The introduction of smokeless powder will do away with the "smoke" question. For efficient service, it is absolutely necessary that the battery commander shall be able at all times to see his target, and at the same time be in communication with his gun commanders and ammunition sergeants.

Trouble was anticipated with the carriage in No. 2 emplacement, as it had never recoiled properly. All the oil in the cylinders was removed but 8 gallons, which proved to be about right as the gun recoiled nicely throughout the practice. But the service of this carriage was very difficult. Extra cannoneers had to be put on the tripping detail and traversing detail and also on the elevating detail. In all eighteen cannoneers were required at this piece. If my recommendation would be of any weight, I should earnestly recommend that this carriage be replaced by a later model of the regular pattern. It is an "experimental" pattern, and has never worked well.

In conclusion I would say that at no time was there any difficulty in keeping "in touch" with the Fire Commander, even with the imperfect communications at Redoubt "B", and that at all times, the fire at this redoubt was under the complete control of the Fire Commander.

I find I have not mentioned the ammunition service. This was good throughout the afternoon. The lifts in No. 1 emplacement stuck twice during the afternoon for small fractions of a minute, due to too small clearance, but this did not interfere materially with the service of the piece.

Respectfully submitted,
G. T. Patterson,
1st. Lieut., Artillery Corps.

Fort Monroe, Va., July 19, 1901.

Capt. E. M. Weaver, Art'y. Corps,
Fort Monroe, Va.

Sis:

Concerning the target practice and manning the fire command at this post on the 18th inst., I have to report, as follows:

I had charge of the 8-in. B. L. R. on barbette carriage and the 10-in. B. L. R. on disappearing carriage, model '94—both in the Place of Arms. On account of the distance between these guns, I was obliged to turn over to Lieut. Spinks, Battery Officer of the 10-in. gun, the firing at that gun. I took personal charge of the work at the 8-in. gun,—as this was part of the annual target practice of my company. The work at the 10-in. gun will be made the subject of a report by Lieut. Spinks.

At the 8-in. gun,—The carriage worked perfectly. The breech block of the gun began working hard, as soon as the piece became hot from firing and occasioned a good deal of delay. It would seem that the clearance between the block and its box is not sufficient. The vent became clogged and caused much trouble and some delay. I could not discover any special reason for this. The lanyard broke at two different times. This suggests the advisability of firing by electricity, which, in my opinion, ought always to be done. Delay was caused at one time, due to the fact that the plotting board did not cover the entire field of fire of the gun. During part of this time, in fact, the gun was masked by Redoubt "A".

Very Respectfully,
T. W. Winston,
Capt., Art'y. Corps.

BATTERY COMMANDER'S RECORD.

The carriages worked satisfactorily except No. 1 carriage failed to run in battery when tripped the first time; had to be started with hand-spikes. Same carriage failed to run in far enough when tripped the second time. Worked satisfactorily thereafter.

Both breech blocks worked stiffly during insertion, especially for the last three inches. No. 2 gun returned into battery after last shot.

Elevating band on No. 2 gun had been shifted during previous firing, causing an error of 10′ in elevation.

Two missfires occurred at No. 1 gun.

Recommend that fire commander's line be run to battery commander's station instead of into the plotting house.

Recommend that loading platform be widened.

Redoubt "C", W. P. Pence,
July 18, 1901. 1st. LIeut., Art'y. Corps,
Battery Commander.

On July 18th the 10-in. gun in my charge was a part of Captain Winston's command. I was acting merely in the capacity of Battery Officer.

I remember very little of the details except that the pawls on the carriage would not, of their own accord, engage in the racks and that not one of the three shots fell between the targets, which was, I have reason to believe, the fault of the gunner.

M. G. Spinks,
Lieut., Art'y. Corps.

A BATTERY MANNING DRILL.

INTRODUCTARY NOTE.

It has seemed to some officers of Artillery that the present Drill Regulations for Coast Artillery might be modified to advantage in some respects. It is rather a difficult matter to pick out the duties of the fire commander, the battery commander, the battery officer, the range officer and the gun commander, to coordinate them all for work at the guns under Case I, Case II and Case III, to separate the prescribed preparatory duties from those pretaining strictly to the actual working of the material in drill, to differentiate the work of the range and position finding personnel from that at the guns and, at the same time, to discover the manner in which the former should meet the requirements of the latter under each of the three "Cases" of firing.

It has seemed also that it is desirable to draw up a drill which will cover all that is to be done by a compauy of coast artillery in manning a battery for drill or action, from the time of formation until it is dismissed after drill or action, and to place in connection with such a drill all the duties of individuals referred to above, classified, and placed together in working relation with respect to each other.

In attempting to accomplish the above, one or two features have been introduced which have been found of service in drilling. Among them may be specified:

1. Each distinct division of work has its own *chief* who is responsible for the efficiency of the materiel to the service of which his sub division is assigned, and for the drill efficiency of the personnel of his sub division. Thus each higher officer from the fire commander down to the smallest sub-division chief looks to one individual, only, as responsible for the efficiency of both materiel and personnel. There will be found therefore in the drill "chiefs" of all divisons and sub-divisions down to the "details."

2. The battery appears to be divided naturally into three divisions, namely, the gun divisions, the ammunition divisions and the range and position finding division. Following this, the name "Division" is assigned to the personnel assigned to each. The company formed for manning the battery is, therefore, divided into a Gun Division, and Ammunition Division for each gun and a Range Division for each battery. Each of these is sub-divided into such "Details" as is found to be desirable to perform the work smoothly and expeditiously.

3. The work of the Range Division is considered a *continuous* operation. Once the target is taken up by a position finder in "tracking," its locus is determined as a continuous operation at regular intervals of time; the proper "corrections" are made for the plotted points by the *Range Division* and the "corrected" range, deflection or azimuth is supplied to the gun; that is, the function of the Range division is considered to be to turn out a *finished* product, not an incomplete one. By this method the men at the guns know constantly the "corrected" range and the "corrected" azimuth or deflection not only for the "present" instant, but for a time *in advance* of the "present" time, always sufficient to allow for accurately setting the range and deflection scales for the firing instant.

Those at the guns being thus relieved of the necessity of making "corrections" for range and azimuth or deflection, have the simpler duty to perform of keeping the scales set merely for the "corrected" determinations of the Range Division, which are clearly exhibited before them together with the *corresponding time relation*. The gun may thus be aimed or laid *accurately* and fired, as rapidly as it can be loaded, or it may be aimed or laid, just as accurately, for any prediction instant in advance. It may be fired by salvo or by single gun, at the gun itself or from the position finder station or any other point. The arrangements and method obviate in large measure the difficulties which beset the battery commander, the gun commander and gunner in attempting to work "corrections" and "allowances" for range and azimuth or deflection while their attention, to some extent, must be given to other matters connected with the service of the gun.

5. The same method applies practically for Case I, Case II and Case III. The only changes in the duties of any importance being in those of the gunner, and consist of only one in each "Case"; in Case I the gunner gives elevation and deflection; in Case II, deflection only; in case III, azimuth instead of deflection.

It is desired to state clearly that it is known that there are certain details about which there exist a diversity of views among artillery officers. The aim has been to keep *the work at the guns* simple and duties clearly divided.

No doubt modifications will suggest themselves. The drill is, indeed, regarded merely as suggestive, and is published solely with a view to developing further discussion and the presentation of views of other officers.

1. The officers and men assigned to the service of any particular class or division of Coast Artillery material constitute the *manning body* of that material.

2. The term "battery", as used in this drill, includes the guns or mortars served by one company of Coast Artillery, together with all public property required for their proper mounting and service.

3. The *manning body* of a *battery* is, therefore, a *company*. The number of officers, non-commissioned officers and privates in a *battery manning-body* will vary in accordance with the number, size and kind of pieces mounted. The Coast Artillery Company is, therefore, a unit of variable size.

4. The company is sub-divided into *manning divisions*, or, simply, *divisions*, made up of the officers and men assigned to certain specific duties, in connection with the service of the battery subdivisions of material.

5. The manning divisions of a battery are:—

I. The Gun Divisions.
II. The Ammunition Divisions.
III. The Range Division.

6. The *gun division* is charged with *loading*, *aiming* and *firing* the guns, (or mortars) of the battery; the *ammunition division*, with serving the powder and projectiles from the powder magazine and the projectile room to the guns (or mortars); the *range division*, with determining the corrected range and deflection (or azimuth) of the target and with furnishing this information to the gun division.

7. Each *division* is sub-divided into such *details* as may be necessary to accomplish best the work with which it is charged.

8. The officers and men are, in so far as possible, assigned in a permanent way to *divisions;* in each *division*, to *details;* and in each *detail* to *posts*, the posts are designated by numbers.

9. A list of names of the company, showing the assignment to *divisions*, *details* and *posts* is called a *manning table*.

10. The commissioned complement of a battery consists, as a rule, of

1. The *battery commander*.
2. The *battery officer*.
3. The *range officer*.

11. Each *division* and each *detail* has its own *chief* who will command his own sub-division whenever it acts separately.

12. Each *chief* is responsible for the efficiency of the material

to which his *division* or *detail* is assigned, and for the *drill-efficiency* of his own *sub-division.*

13. The company in forming for drill or action will assemble on the *Company Parade*, in line, in two ranks, facing to the front, the *gun division* on the right, the *ammunition division* on the left of the *gun division*, for each gun, in order of the emplacement numbers of the guns from right to left; the *range division* will form on the left of the *entire manning-body*.

14. The position of the officers, non-commissioned officers and trumpeters in line are as follows:

Battery commander: twelve yards in front of the center of the line, facing the battery.

Battery officer: six yards in front of the center of the right-half of the battery, facing to the front.

Range officer: six yards in front of the center of the left-half of the battery, facing to the front.

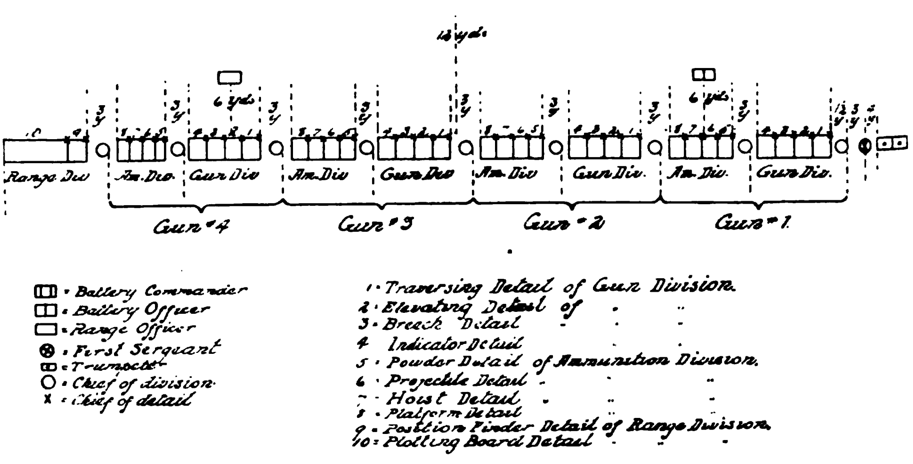
First sergeant: two yards to the right of the chief of the first gun division, in line with the front rank.

Trumpeters: side by side, on line of front rank, four yards to the right of the first sergeant.

Chiefs of Divisions: on the line of the front rank, one yard to the right of their own division and one yard to the left of the division on their right, uncovered in the rear rank.

Chiefs of Details: on the right of the front rank of their own details, covered in the rear rank by *number one* of the *detail.*

Battery Manning Body Formed in Line.



15. To form the company for drill, or action, the *first sergeant*, at the sounding of the assembly, takes post on the Company Parade, six paces in front of the point where the middle of the company is to rest, and, facing in the direction of that point, commands: FALL IN. At this command the *chiefs of divisions* and *chiefs of details* take their proper places in line; the members of the several details form promptly on the chiefs of their respective details. In each *gun division* the *details* will form in the following order from right to left: 1. *breech detail*, 2. *traversing detail*, 3. *elevating detail*, 4. *indicator detail*. In each *ammunition division* the details will form as follows: 1. *powder detail*, 2. *projectile detail*, 3. *hoist detail*, 4. *platform detail*. The *range division* will form as follows: 1. *position finder detail*, 2. *plotting board detail*.

In so far as practicable, the regular members of each detail fall in from right to left in the order of their numbers, odd numbers in the rear rank, even, in the front rank.

The Supernumeraries of each detail fall in on the left of the regular numbers.

The trumpeters take their position in line.

As soon as the ranks are formed, the first sergeant calls the roll of the company.

Absentees are replaced, in so far as possible, from the supernumeraries assigned to those details in which the absences occur.

The *first sergeant* having called the roll and completed the details, commands: CALL OFF. At this command each detail "calls off" from right to left, the odd numbers in the rear rank, the *chiefs of details* and even *numbers* in the front rank. The first sergeant then faces about, and, when the *battery commander* takes his position, salutes and reports the result of the roll call to him.

The *battery officer* and the *range officer* take their respective places in line.

16. The *manning-body* is formed in column, for marching, by the command: 1 *Right* 2 FACE.

At the command *face*, the *battery officer* takes position on the left of the *chief of the first gun division*; the *range officer* takes position on the left of the *chief of the range division*; all in ranks face to the right; the *trumpeter* who is in rear after facing, steps up on the right of the trumpeter in front of him; the *battery commander* faces to his left.

17. A *manning-body* in column is marched and direction is changed as explained for a column of files in Infantry Drill Regulations. While marching the column will extend to easy marching distance from breast to back throughout; on halting, all will close

up without command to such distance, that, on facing into line, they will occupy their proper places. The *battery commander* will march in such position as will enable him best to direct the movements of the column.

To Man the Battery.

18. The *company* being formed, as explained above, in line, the *battery commander* faces it to the right and moves it by the most convenient route to the *battery*.

As the battery is approached, he commands: 1. *prepare for drill* (*or action*) 2. DIVISIONS POST.

At the second command each *chief of division* will step to the left, out of column, to a point opposite the middle of his *division*, and give such commands as may be necessary to conduct his division by the most direct route to the particular material to the service of which his division is assigned.

If he so desire, the *battery commander* may "post" the *divisions* separately, at any point of the march, by commanding:

(SUCH) DIVISION POST.

At this command the chief of the division designated steps out of column, as explained above, and moves his division by the most expeditious route to its *post*.

The *battery officer* falls out with, and accompanies the *gun division*; the *range officer* does the same, with the *range division*.

When a division arrives at its *post* the *chief of division* commands: 1. *prepare for drill* (*or action*), 2. DETAILS POST, at the second command each *chief of detail* commands: POST. At this command each number moves briskly, takes up the implements assigned to him and then takes his individual post and proceeds at once to make all necessary preparations for drill (or action) and, having completed these preparations, takes position at his post ready for service.

Composition of the Divisions of a Battery Manning Body.

19. THE GUN DIVISION is composed of:

1. One chief of gun division, "gun commander."
2. The *traversing detail*, composed of:
   (a) one chief of traversing detail, "gunner;"
   (b) numbers 1 to 4 (as many as may be required to traverse the piece, as given in the *manual* of the piece.) for each piece.
3. The *elevating detail*, composed of:
   (a) one chief of elevating detail;
   (b) numbers 1 to 4 (as many as may be required to elevate the piece, as given in the *manual* of the piece.) for each piece.
4. The *breech detail*, composed of:

(a) one chief of breech detail;
(b) numbers 1 to 8 (as many as may be required to open and close the breech block, handle the sponge and rammer, insert and force home the projectile and powder, as given in the *manual* of the piece.) for each piece.

5. The *indicator detail*, composed of:
   (a) one chief of indicator detail, range recorder;
   (b) number 1, deflection recorder;
   (c) number 2, range receiver;
   (d) number 3, deflection receiver.

20. THE AMMUNITION DIVISION is composed of:

1. One chief of ammunition division.
2. The *powder detail*, composed of:
   (a) one chief of powder detail;
   (b) numbers 1 to 4 (as many as may be required to handle cartridges and to deliver them to the hoist, as given in the *manual* of the piece.) for each piece.
3. The *projectile detail*, composed of:
   (a) one chief of projectile detail;
   (b) numbers 1 to 6 (as many as may be required to handle the projectile and deliver them to the hoist, as given in the *manual* of the piece.) for each piece.
4. The *hoist detail*, composed of:
   (a) chief of hoist detail;
   (b) numbers 1 to 7 (as many as may be required to place the powder and projectiles on the hoist, and to raise the same to the gun platform above, as given in the *manual* of the piece.) for each piece.
5. The *platform detail*, composed of:
   (a) one chief of platform detail;
   (b) numbers 1 to 3 (as many as may be necessary to handle the projectiles and powder on the gun platform as delivered by the hoist, as given in the *manual* of the piece.) for each piece.

21. THE RANGE DIVISION is composed of:

1. One chief of range division.
2. The *position finder detail*, (for each position finder) composed of:
   (a) one chief of position finder detail, observer;
   (b) number 1, instrument reader and recorder;
3. The *plotting board detail*, (for each battery) composed of:
   (a) one chief of plotting board detail, plotter;
   (b) number 1, plotting board recorder;
   (c) number 2, range table reader;
   (d) number 3, corrected range computer;

(e) number 4, deflection table reader;
(f) number 5, corrected deflection computer;
(g) number 6, corrected range transmitter;
(h) number 7, corrected deflection transmitter.

22. *Chiefs of division* will be appointed from the *sergeants*; *chiefs of detail*, from the *sergeants, corporals or privates*, according to the importance of the position and the special qualifications of the individual.

23. Duplicate *relief details* will be provided for the *breech detail, the powder detail, the projectile detail, the hoist detail and the platform detail* whenever the practice is likely to continue so long as to unduly fatigue the regular numbers of these details. *Chiefs of division*, in continuous firing, will give instructions for shifting reliefs, at such times as to avoid excessive fatigue on the part of those numbers in service.

Supernumeraries will be assigned to each detail of the battery; vacancies in a detail will be filled, as far as possible, from the supernumeraries assigned to it.

24. From the time the manning body is posted until it is withdrawn, the duties of the body may be divided into three classes as follows:

1. Preparatory duties;
2. Serving duties;
3. Securing duties.

The first, includes all those duties which must be performed by each member of the manning body, in order to prepare for service the material to which he is assigned; the second, those duties connected with the service of the pieces in drill (or action) under Case I, Case II and Case III; the third, those necessary at the close of drill (or action) in order to leave all material secure and in serviceable condition.

25. *Preparatory duties* may be enumerated as follows:

Battery Commander:—After commanding DIVISIONS POST, (section 18) he goes to the "battery commander's station" and on arriving there sees that the battery commander's chart, the identification book and the armor attack sheet are taken out and conveniently placed; that the battery commander's instrument for the observation of fire (if one is provided) is set up and adjusted for use; receives reports from the *battery officer* and the *range officer* as to condition and readiness of the *gun, ammunition and range divisions;* if the *fire-command* be manned, reports to the *fire commander* the condition and readiness of his battery, and receives from him orders as to the particular target to be attacked and such other general or special instructions as he may give; gives orders to the *battery officer* as to the particular target to be attacked, whether fire shall be by piece or salvo, at will or controlled by the battery commander, whether Case I, Case II or Case III will be used, the rate of prediction, the rate of fire and kind of projectiles; gives orders to the *range officer* as to the *rate of plotting and predicting* whether, Case I, Case II or Case III will be used, and, if Case III, whether the range and azimuth of the "set back point" shall be sent to him.

Battery Officer:—After the command DIVISIONS POST (section 18) he supervises the posting of *divisions, details and numbers* of the gun and *ammunition divisions;* sees that all movements are made with life; that equipments are gotten out and prepared for use, in accordance with the manual of the piece; that all necessary preliminary adjustments are made to elevating, traversing and recoil mechanisms; inspects the material and personnel of all *traversing, elevating, breech, indicator, magazine and platform details* for each gun emplacement; receives reports from each *chief of division* as to the condition and readiness of material and personnel under them, respectively; that the *duplicate breech and magazine details and supernumeraries* of other *details* are conveniently posted for *relief purposes;* reports to the *battery commander* the condition and readiness of the material and personnel pertaining to the *gun and ammunition divisions;* receives orders from the *battery commander* as to the particular target to be attacked; whether fire shall be by piece or salvo, at will or controlled by the *battery commander,* whether Case I, Case II, or Case III, will be used, the rate of fire, the rate of prediction, and the kind of projectiles, and such other general or special instructions as the *battery commander* may see fit to give him.

Range Officer:—After the command DIVISIONS POST (section 18) he supervises the posting of the *range division* and of its *details;* sees that all movements are made with life; that equipments are gotten out and prepared for use; that all necessary and preliminary adjustments are made to the position finder, the telephones, the telautographs, time keepers, wind recorders and other instruments or apparatus requiring adjustment prior to use, to the service of which the *range division* is assigned; inspects the material and personnel of the *position finder and plotting-board details*; receives a report from the *chief of the range division* as to the result of his inspection of personnel and material of the *division;* that supernumeraries are conveniently posted; reports to the *battery commander* the condition and readiness of the material and personnel pertaining to the *range division;* receives orders from the *battery commander* as to the rate of plotting, the rate of predicting, whether Case I, Case II, or Case III, is to be used, and if Case III, whether the range and azimuth of the set back point will be sent.

The First Sergeant:—After the command DIVISIONS POST (section 18) he proceeds directly to the *battery commander's station,* takes out and prepares ready for use, the battery commander's chart, the ship identification book, the armor attack sheet, the battery commander's tables; sets up and adjusts ready for use, the battery commander's instrument for the observation of fire (when such an instrument, other than the battery position finder, is provided); stands near the battery commander's station ready to assist as he may be directed by the *battery commander.*

The Trumpeters:—After the command DIVISIONS POST (section 18) they take post three yards in rear of the *battery commander* and remain in that position or near him, ready at all times to act as orderlies, to sound signals, or perform other special duties.

The Chief of the Gun Division:—After the command DETAILS POST (section 18) he supervises the posting of the *details and numbers* of his division; sees that all move with life to their respective posts; that each *chief of detail and number* promptly equips himself for service, and prepares for use, the material to the service of which he is assigned, making such tests and adjustments as may be necessary to insure that the material is in perfect working order. In this supervision he will observe that breech and muzzle covers are removed, folded and carefully laid aside, the breech opened and the vent is cleared; the bore, chamber, breech box, breech block and breech mechanism are examined and the parts needing it cleaned, the recoil cylinders are opened and examined, filled, if necessary, and securely closed; the elevating and traversing gears are tested for smooth and easy working; the azimuth indicator is tested for adjustment; the level of the traverse circle is tested (if the level of the carriage has not recently been determined); the sights and quadrants are examined; the telephone, telautograph or other line of communication to and from the gun platform are tested. He makes an inspection of the piece, the working of the breech block, the adjustment of the obturator, the equipment of the breech detail especially the lanyard and primers; the carriage, its traversing, (verifying the adjustment of the azimuth scale), its elevation and depression, (verifying the calibration of the quadrant scale on the elevating arc); the sight standard, (verifying the adjustment of the sight standard in azimuth, when the sight is in its seat, and the sight bracket on trunion with sight on bracket, noting that the proper difference of reading exists, for a given sight setting, between the sight and quadrant. He will see that the throttling valve of the recoil cylinders is properly set; that counterpoise weights are properly adjusted for the muzzle velocity and projectile to be used; that the sponge and rammer are in good order and properly placed; that the telephones or telautographs connecting with *plotting-board detail* are in good working order; that the *indicator* board is clean; that the "present time" indicator is adjusted to the *fire command time*. He reports to the *battery officer* when ready for service: RANGE DIVISION IN ORDER.

The Chief of the Traversing Detail of the Gun Division:—After the command DETAILS POST (section 18) he gets the sight, if not already equipped with it; sees that the *numbers* of his detail get and take up to the gun the implements pertaining to their duties, as prescribed in the manual of the piece; sees that the *numbers* go promptly to their respective posts at the carriage; mounts to his own post; places the sight in its seat, or on the sight brackets; verifies the adjustment of the sight standard for azimuth by directing the gun on some point the azimuth of which is known and noting the azimuth reading; reports to the *chief of gun division* when all is in order: TRAVERSING DETAIL IN ORDER.

The Chief of the Elevating Detail of the Gun Division:—After the command DETAILS POST (section 18) he gets the quadrant; sees that the *numbers* of his detail get and take up to the gun the implements pertaining to their duties, as prescribed in the manual of the piece, and go promptly to their respective posts. In case the level of the azimuth circle has not been tested recently he causes one number to mount on the gun with quadrant and he verifies the reading of the elevation scale in several positions in azimuth, or determines the index error for different positions in azimuth; he verifies the accuracy of the readings of the elevating device of the carriage by comparison with the reading of the quadrant in several positions of elevation; reports to the *chief of gun division* when ready for service: ELEVATING DETAIL IN ORDER.

The Chief of the Breech Detail of the Gun Division:—After the command DETAILS POST (section 18) he sees that the *numbers* of his detail get and take up to the gun the implements pertaining to their duties, as prescribed in the manual of the piece, and that the *numbers* of his detail equip themselves properly for service; he sees that the muzzle and breech covers are taken off, folded and carefully laid aside; that the bore and chamber of gun are clear and clean; that the breech box is clean and oiled, that the breech block threads and slots are clean and oiled; that the obturator is properly adjusted and the locking nut on spindle is screwed up tightly; that the recoil cylinders are filled; that the counterpoise weights are adjusted properly for the muzzle velocity and projectile to be used; that the throttling valve of recoil cylinders is properly set; when all is ready for service he reports to the *chief of the gun division:* BREECH DETAIL IN ORDER.

The Chief of the Indicator Detail:—After the command DETAILS POST (section 18) he directs his detail to take up and place in position the *indicator board,* and then sees that the telephone and telautograph receivers are in position and in working order; that the *numbers* of his detail take their respective posts promptly; that the indicator board is clean; that the "present time" indicator is set to the fire command time (from time to time he will verify this setting, if necessary changing the rate of the time keeper by means of its regulator); when ready for service, reports to the *chief of gun division*: INDICATOR DETAIL IN ORDER.

The Chief of the Ammunition Division:—After the command DETAILS POST (section 18) he supervises the posting of the *chiefs of detail* and *numbers* of his division; sees that all move with life to their respective posts; that each *chief of detail* and each *number* prepares promptly for use the material to the service of which he is assigned. He has made such tests and adjustments as to insure that the material is in good order. He has the magazine and shell room lighted. He arranges for handling expeditiously such charges and projectiles as are likely to be required in the firing. He has tested the trolleys, trucks, hoists (by both hand and electric power), telephone line to and from the battery officer's station. He reports to the *battery officer* when ready for service: THE AMMUNITION DIVISION IN ORDER.

The Chief of the Powder Detail of the Ammunition Division:—After the command DETAILS POST (section 18) he proceeds with his detail to the powder magazine, lights it, arranges the charges conveniently for handling, makes a record of the marks on each section of cartridges laid out for use; when ready for service reports to the *chief of the ammunition division:* POWDER DETAIL IN ORDER.

The Chief of the Projectile Detail of the Ammunition Division:—After the command DETAILS POST (section 18) he proceeds with his detail to the projectile room, lights it, arranges a number of each kind of projectiles conveniently for handling; tests the workings of trolleys and trucks; sees that all shell set apart for use are properly fuzed, and, when necessary, that the bases of shell are protected by copper disks; that projectiles are cleaned and oiled ready for inserting in the gun; makes a record of the kind and weight of the projectiles laid out for use; when ready for service reports to the *chief of his division:* PROJECTILE DETAIL IN ORDER.

The Chief of the Hoist Detail of the Ammunition Division:—After the command DETAILS POST (section 18) he proceeds with his detail to the ammunition hoist; test the hoist thoroughly by electricity and by hand; sees that all gearing and mechanism is clean, oiled and in smooth working order; when ready for service reports to his *chief of division:* HOIST DETAIL IN ORDER.

The Chief of the Platform Detail of the Ammunition Division:—After the command DETAILS POST (section 18) he proceeds with his detail to the gun platform; sees that all trucks have their wheels oiled, and their gearings clean, oiled and in smooth working order; arranges trucks so as to have a "relay" supply of ammunition on trucks, in which relay shall be represented one of each kind of projectile to be used, completes the relay supply; posts *numbers* at the relay; takes post himself near hoist; when ready for service reports to the *chief of his division:* PLATFORM DETAIL IN ORDER.

The Chief of the Range Division:—After the command DETAILS POST (section 18) he supervises the posting of the *details* and *numbers* of his division; sees that all move with life to their respective posts; that each *chief of detail* and *number* promptly prepares for use the material to the service of which he is assigned. He has made such tests and adjustments as may be necessary to insure that the instruments, appliances and apparatus are in good working order, including, leveling the position finder, testing the smooth and easy working of all parts of this instrument, determining height of base and applying correction for same, setting the altitude scale, adjusting the range reading, making correction for abnormal refraction, verifying the azimuth reading, verifying the adjustment of the replotting device, verifying the azimuth and range scales of the battery plotting board, preparing for use the set back chart and prediction rule, testing all lines of communication to and from the station, giving to *indicator details* on gun platforms the correct "present time." He sees that the *range-table reader* is equipped with proper range table, and the *deflection table reader* with proper deflection table; that computers and recorders are properly equipped for their work. He makes a general inspection of all material pertaining to his division and verifies such of the above tests and adjustments as he may think desirable. He reports to the *range officer*, when ready for service: THE RANGE DIVISION IN ORDER.

The Chief of the Position Finder Detail of the Range Division:—After the command DETAILS POST (section 18) proceeds with his detail to the position finder, has the station opened, uncovers the instrument, notes the reading of the tide-guage, verifies the level of the position finder table, applies tide correction to altitude scale, verifies reading of range scale by directing telescope on a group of datum points at close, mid and long ranges, making correction for abnormal refraction, verifies the reading of the azimuth of the datum points; if the instrument hasre plotting device and it is to be used, verifies the setting of this device; sees that the instrument reader and recorder is at his post equipped with reading glass (if necessary) and record blank; reports to the *chief of his division:* THE POSITION FINDER DETAIL INORDER.

The Chief of the Plotting Board Detail of the Range Division:—After the command DETAILS POST (section 18) proceeds with his *detail* to the battery plotting board, uncovers the board, folds and lays aside the cover, applies the plotting rulers or arms to the board, tests the range and azimuth of certain known datum points, gets ready for use the predicting rule and the set back charts and its rulers; sees that the proper range and deflection tables are supplied to the *range table reader* and the *deflection table reader*, respectively; that the corrected rangeand corrected deflection computers and recorders are at their posts and ready for service; that the corrected range and corrected deflection transmitters are each at their instruments ready to send the corrected range and corrected deflection to the range and deflection recivers at the indicator board; that the "present time" is sent promptly and accurately to the *chief of the indicator detail*; when all is ready for service, reports to the *chief of his division:* THE PLOTTING BOARD DETAIL.IN ORDER.

25. *The Serving Duties* of a battery manning body may be enumerated as follows:

The *battery commander* having had a certain designated target assigned to him for attack by the *fire commander*, or in case none is so assigned, having independently selected such a target for attack, ascertains promptly from the identification book (if he is not already informed in regard thereto) the distinguishing features of the target; the kind, distribution and thickness of its armor; the character and distribution of its armament. He then decides whether the fire shall be by salvo or single gun, and whether Case I, Case II, or Case III shall be followed.

If Case I or Case II is to be followed the *range, ammunition and gun divisions* would work, in combination, as follows:

The *battery commander* informs the *battery officer* as to the identity of the target, the kind of fire to be used, and the particular Case to be followed. He also, prior to the first shot, and, from time to time, during the firing, gives directions to the *battery officer* as to what kind of projectiles shall be used. He also puts the *observer* of the position finder on the target. He then orders:

PREPARE TO TRACK.

This order is transmitted at once to the *battery officer* and to the *range officer*, each of whom commands: PREPARE TO TRACK; this command, as given by the *battery officer*, is repeated by the *chief of each gun division*, is transmitted to the *chief of each ammunition division* by the *chief of his platform detail*, and is repeated below by the *chief of each ammunition division.*

At these commands the entire personnel of the battery takes position in readiness for immediate service. As soon as this condition obtains in the *gun and ammunition divisions*, the *battery officer* reports, "IN ORDER," to the *battery commander*; likewise, as soon as it obtains in the *range division* the *range officer* reports, "IN ORDER," to the *battery commander.*

As soon as these reports are in, the *battery commander* orders:

TRACK.

At this command the *observer** "follows" the target by keeping his telescope on it constantly,† the *instrument reader* listens for the warning signal bell, and, at the "take" stroke of the bell, the *observer* stops the movement of "following" until the *instrument reader* reads off, in a loud clear voice, (1) the *azimuth* and (2) *range*; as soon as this is done, the *observer* "picks up" the target again, and keeps on it until the next "take" signal of the bell, and this process is continued indefinitely, as long as the "tracking" is required by the *battery commander.*

The instrument reader and recorder enters the *azimuth and range* in his record. If the *position finder and the battery plotting board* are not in the same room, the *azimuth and range* are transmitted immediately by telephone or telautograph to the *plotting board* and the point plotted at once thereon; if they are in the same room, the point is plotted directly from the call-off of the *instrument reader and recorder.*

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* In case a horizontal position finder be used there will be a second *observer*, a second *instrument reader* and a second *recorder* at the distant station, connected with battery station by telephone or telautograrh. The preparatory command "prepare to track" will be transmitted to the distant station, also all information relating to the identification of the target.

† When the tracking continues for a considerable time, and the *observer* feels eye-fatigue coming on, he will shift positions with the *instrument reader* or *recorder* until his eye is rested. One observer continuously should be able to "follow" for about one hour.

The *plotter* of the *plotting board detail* plots all the points; the *predicting officer* (usually the *range officer* himself) makes all predictions and determines the *set-back* point.

When three points have been plotted, the predicting officer applies his predicting ruler and marks on the plotting chart the predicted point, corresponding to the predicting time interval previously prescribed by the battery commander. The *azimuth and range* of the predicted point are at once determined and called off by the *plotter* and entered in the *plotting board record* by the plotting board recorder. *The predicting officer,* in the mean time, determines the *set-back,* marks the point on the target's course; the *plotter* at once determines the *azimuth and range of the set-back point,* calls them out and these are also entered on the plotting board record.

The predicting officer calls out the "prediction time" for each prediction he makes. The *plotter* calls out the *azimuth and range* (1) of the "plotted points" from the position finder; (2) of the "predicted points" from the gun; (3) of the "set back points". The *azimuth and range of the set-back point* will be "*from the gun,*" or "*from the battery commanders station,*" according to the orders of the *battery commander,* depending on whether the guns are to be fired at the battery or at the battery commanders' station.

The plotting board record may be arranged as follows:

Prediction Time.	Plotted Points.		Predicted Points.		Set Back Points.			
					From Gun.		From B. C. Station.	
	Azimuth	Range	Azimuth	Range	Azimuth	Range	Azimuth	Range
H. M.	° ′	yds.	° ′	yds.	° ′	yds.	° ′	yds.

Unless otherwise directed, the plottings will be made each minute; the predictions will be made once a minute after the first three plottings; the set back will be determined and marked immediately after each prediction.

In calling off *azimuths, ranges, predictions, time and corrections,* those charged with this duty will be careful to speak in a clear voice, and loud enough to be heard by those who are to make use of the data called off, but no louder than this.

The *range table reader* enters his correction table with the called *range* of each predicted point, calls out the proper values for the corrections for the *density of the air, the height of tide, the velocity of wind along the range* (the reading of the wind indicator, as to direction and velocity of the wind, must be visible to the range table reader or must be communicated to him.)

The *range computer* takes down: 1. the prediction time; 2. the predicted range; 3. the range corrections. He quickly applies the *range corrections* to the *predicted range* and calls out the resulting corrected *predicted range with its corresponding prediction time*, to the range *transmitter.*

The *range transmitter* listens carefully for the call of the *range computer*, and as soon as he hears a *corrected-range-time relation* called off, he transmits it at once to the *range receiver or the indicator board.*

The *range receiver* at the indicator board at once repeats the *corrected-range-time relations* to the *range indicator.*

The *range indicator* keeps entered on the indicator board the *prediction time* to the nearest ten-minutes, and following down the proper *minute-line* makes a cross opposite that point of the range scale given on the left of the board which corresponds to the corrected predicted range, thus plotting on the indicator-board the corrected predicted range-time relation.*

The *deflection table reader* enters his correction table with the predicted range, and calls out the corrections for *drift* and *wind across range* (the reading of the wind indicator, as to *direction* and *velocity* of the wind, must be visible to the deflection table reader or must be communicated to him).

The *deflection computer* takes down: 1. The prediction time; 2. the azimuth of the predicted point; 3. the azimuth of the set-back point; 4. the deflection corrections. He takes the difference between "2" and "3", affects it with the proper sign and applies to this difference, "4", with proper signs; the *resulting corrected deflection, he calls out with its prediction time to the deflection transmitter.*

The *deflection transmitter* listens attentively for the call of the deflection computer, and as soon as he hears a corrected deflection-time relation called off, transmits it at once to the *deflection receiver* at the indicator board.

The *deflection receiver* at the indicator board, at once repeats

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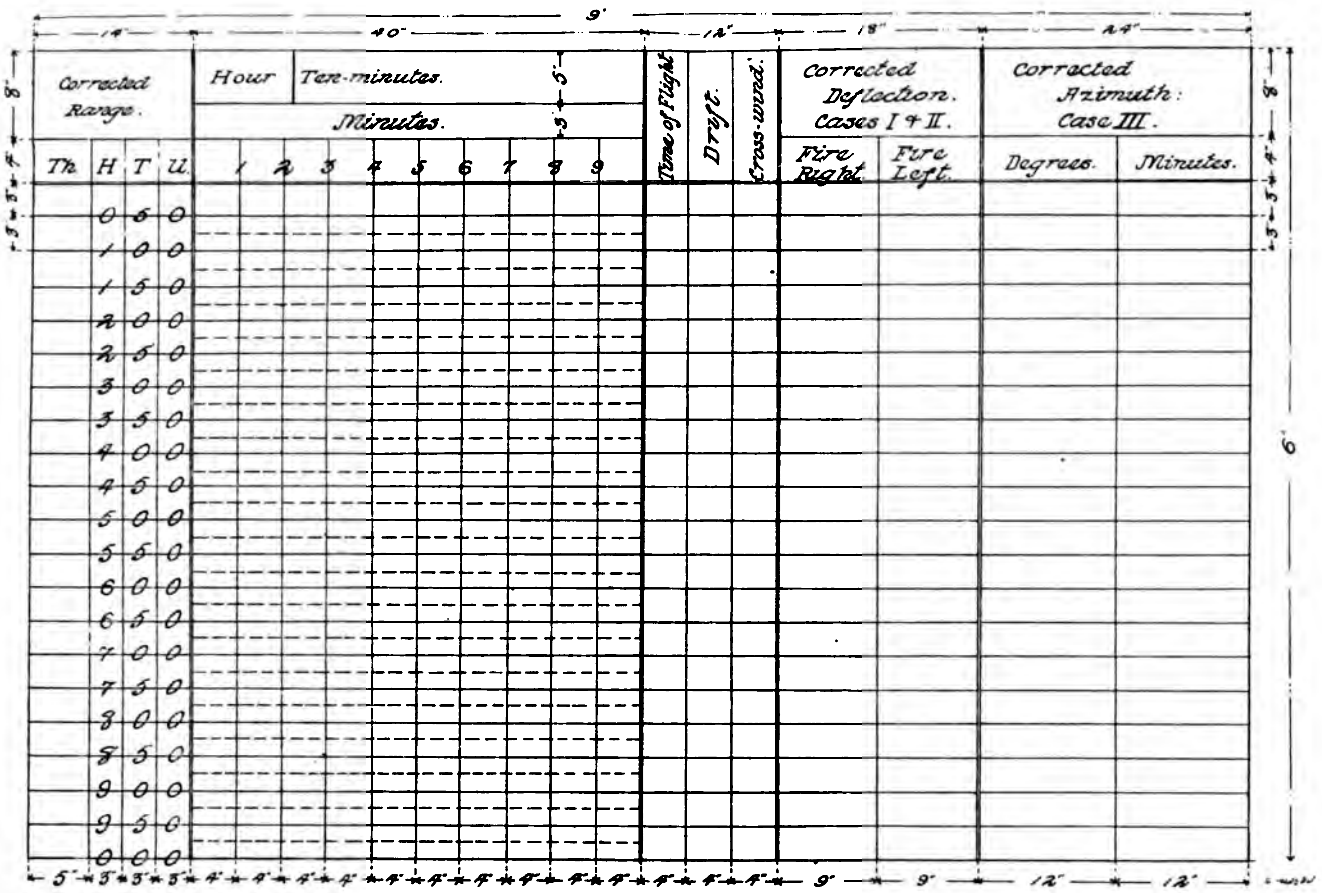
* From the instant of observation to the instant of recording on the indicator board the corrected range and corrected deflection (or azimuth) the time interval is easily within one minute. This will always make the indicator board record in advance of the "present time." That is the *corrected* conditions for *range* and *deflection* (or *azimuth*) are continuously in evidence before those at the guns.



Design for an Indicator Board.

If the change in range is greater than 200 yds. per minute the range scale on left of board should be doubled, the unit representing 100 yds. instead of 50 yds. Colums headed "Time of Flight", "Drift" and "Cross-wind" only to be used when work of Range Division breaks down.

the corrected deflection-time-relation to the *deflection indicator.*

The *deflection indicator* immediately enters on the indicator board the deflection in its proper column, opposite the proper *time* cross, made by the indicator on the time minute line.

Case III is conducted in the same manner, in so far as "following," "predicting," "correcting," "transmitting" and "indicating" are concerned, except that the *azimuth* of the *predicted point* is sent to the indicator board, corrected for *drift* and *wind across range* instead of corrected deflection.

In case the *battery commander* is to fire the battery, in addition to the above, the *range officer* will send to the *battery commanders' station* the *azimuth and range* of the "set back from the battery commander's station."

In the foregoing, the *serving duties* of the *range division* have been given from the *observation* of the targets' position, continuously through, until the *corrected range, corrected deflection* and *prediction time* are displayed on the *indicator board* in such a way that the *chief of the traversing detail* and the *chief of the elevating detail* of the *gun division* may at all times during the "tracking," have in clear view the *corrected predicted range* and the *corrected deflection* (or *corrected azimuth* under Case III,) corresponding to the *prediction time,* which time will always be in advance of the *present time* (allowing a predicting interval of two minutes, and one minute from the "observation" to the posting of the corrected range-deflection-time on the *indicator- board*).

The *serving duties of the gun division* will now be given.

Serving Duties of the Gun Division.

These will be taken up, in order, under Case I, Case II and Case III.

Case I.—This case is used chiefly with rapid-fire guns. The direction and elevation are given by the gunner himself, and when the electric firing device is used, the gunner also fires the piece. Recent proposed modifications of the carriages of the larger caliber guns place the elevation, traversing and firing under the control of the gunner, through electric motors and geared connections, the same as has existed heretofore only with the rapid-fire guns. In these cases, and in case the quadrant device should in any way become unserviceable, Case I would be used.

In using Case I, the *serving duties* may be performed as follows:

The *corrected predicted range-deflection-time relation* will be displayed on the indicator-board continuously, as explained above.

The *gunner* follows the target, with his sight and keeps its range and deflection scale set continuously to correspond with the *corrected range-deflection* on the *indicator-board*, corresponding to the *present time*. When it is necessary for him to dismount from the carriage in firing, he allows, on his range and deflection scales, for the motion of the target during the time required by him to clear the piece and for time required to "trip" and fire the piece. With these allowances made, he causes the line of sight to be directed on that part of the target it is desired to hit.

As soon as the gun is loaded, the breech closed and the breech block locked, the *chief of the breech detail* calls out: READY, looks to see the *gunner* clear the piece then inserts the primer with lanyard attached; with disappearing mounts he gives the command for tripping the counterpoise and when the gun is "in battery" he breaks away in position ready to fire at the command.

As soon as the *gunner* hears the call READY by the *chief of the breech detail,* he verifies his aim for the instant of firing, allowing for his time of clearing the piece, tripping time and firing time, calls out to the gun commander, SET, removes the sight from its bracket (if necessary) and quickly clears the piece.

The *gun commander* looks to see the *gunner* clear of the piece and when the gun is "in battery" commands: FIRE.

The *gunner,* if possible, notes the effect of the shot, and gives to the *gun commander* the observed values of the errors of range and deflection; he then resumes his post and the operation is repeated.

Each gun is loaded as prescribed in its own manual.

Chiefs of details and *numbers of details,* will, in so far as possible, remain at their posts during the firing.

Case II.—This case should be used, as a rule, whenever the target can be seen from the gun.

The *corrected predicted range-deflection-time relation,* will be displayed on the indicator board as explained above.

In "following" the target over the field of fire, the gunner does the same as in Case I, except that he sets his sight for deflection only.

The *chief of the elevating detail* keeps the index of the elevating device continuously set for the *corrected predicted range* for the *present time,* as shown on the *indicator board,* except during those operations of loading when the load is being inserted and rammed.

The *chief of the breech detail* does as explained under Case I.

As soon as the gunner hears the call "ready" of the *chief of* *the breech detail*, he verifies his aim for deflection, allowing for tripping time and firing time, and calls out: DEFLECTION SET. In like manner, as soon as the *chief of the elevating detail* hears the call "ready" of the *chief of the breech detail*, he verifies the range setting of the elevating device for the instant of firing, and calls out: RANGE SET.

As soon as the *gun commander* hears the calls: "deflection set" and "range set," by the *gunner* and the *chief of the elevating detail*, respectively, and sees that the gun is "in battery," he commands: FIRE.

The *gunner* notes the effect of the shot, and gives to the *gun commander* the estimated values of the observed errors of range and deflection. The operation is then continued.

Each gun is loaded according to its own manual for loading.

When the conditions render it possible, *chiefs of detail* and *numbers of the details*, keep their respective posts during the firing.

Case III.—This case is used with mortars, and when, for any reason, the target cannot be seen from the *battery*. It is also used when the firing is done by the *battery commander* at a distance from the battery, especially when firing by salvo.

The *corrected predicted range*, the *corrected predicted azimuth* and the corresponding *prediction time* are displayed on the indicator board, continuously.

The duties at the gun are the same as in Case II, except that the *gunner* dismounts from the sighting platform, replaces the telescope in its case, and takes his post opposite the azimuth circle's sub-scale. He gives such orders to the *traversing detail numbers*, or so manipulates the traversing motor, as to cause the index of the azimuth sub-scale to read the *corrected predicted azimuth* for the *present time*, or for such *future predicted time* as may be specially ordered by the *gun commander*.

"Following," both for *range* and for *azimuth*, may take place at all times during the operation of loading in Case I, Case II, or Case III, *except* when the projectile is being launched from the truck to the loading tray and being rammed home.

As soon as the *chief of the breech detail* calls: READY, the *gunner* verifies the azimuth setting for the *designated firing instant* and calls out: AZIMUTH SET.

The *gun commander*, *gunner*, *chief of elevating detail*, *chief of breech detail and detail numbers*, in all other respects do as explained under Case II.

Throughout the firing, in all three cases, the *battery commander* observes closely the effect of the firing, and gives such instructions, to the *battery officer* in regard thereto as he may think desirable: the *battery officer* will give such instructions to *gun commanders* as may be necessary to carry out the instructions of the *battery commander*, and the *gun commanders*, in turn, will give the proper orders to *chiefs of details*.

In firing from the battery commander's station by "set back," the observer and *instrument reader* set the instrument on the "set back from the battery commander's station" as soon as the *azimuth* and *range* of the point are received; the *observer* for this purpose stops following the target, and, when so set, reports to the *battery commander*: INSTRUMENT SET. The *battery commander* goes to the telescope and fires the battery as the target comes on the intersection of the vertical and horizontal cross-hairs.

As a matter of fact the target will arrive rarely, if ever, precisely at this intersection, the judgment of the battery commander must therefore be excercised as to whether the battery should be fired when the vertical line is reached or when the horizontal line is reached; that is, whether the chances of hitting would be increased by firing on azimuth indications or on range indications. The former should govern when the range is changing less rapidly than the azimuth; the latter, when the conditions are reversed.

If the departure of the target from the intersection of the cross-hairs is considerable at the expiration of the firing time, the attempt to fire must be abandoned.

These difficulties mark the weak point of firing by "set back," in Case III, and rob the method of that preciseness which was at one time claimed for it.

Securing Duties.

To cease drill (or action), to secure material, to reform the manning-body, to march the manning-body to the *manning-parade* and to *dismiss* it, the *battery commander* causes the "recall" to be sounded by the trumpeters or sends to the *battery officer* and *range officer* the commands: CEASE DRILL, RE-FORM; these commands are transmitted to the *chiefs of divisions* and *chiefs of details;* the *chiefs of details* command:

SECURE MATERIAL.

At this command each number replaces carefully his equipments and secures the material to the service of which he is assigned. As soon as all the numbers of any detail have completed these duties the *chief* of that *detail* commands:

FALL IN.

At this command the numbers fall in, in front of their *chief of detail*, in line, in two ranks.

As soon as a *detail* is thus reformed its *chief* moves it to the point designated as the rendezvous of the *division* to which it belongs.

When the *detail* arrives at the point of *division rendezvous* it is maneuvred to its proper place by the commands of its chief, who then takes his proper position in line.

As soon as all the *details of a division* are assembled, the *chief of division* will take command, march the *division* to the point of rendezvous for the *company*, place the *division* in its proper position in the *company* formation, and then take his own position in line.

As soon as all of the *divisions* have been assembled, the *battery officer* and the *range officer* will take their positions in line, and the *battery commander* will take command of the assembled *company*. The *battery commander* will then march the *company* to the *company parade* and dismiss it there.

The *battery commander* may direct *chiefs of divisions* to march their respective *divisions* off separately and to dismiss them; the *divisions* then will be marched directly from the *division rendezvous* to the *company parade*, formed in line there, and dismissed.

EXTRACT FROM THE PROCEEDINGS OF THE BOARD OF OFFICERS CONVENED AT FORT WADSWORTH, N. Y., PER PAR. 13, S. O. NO. 106, A. G. O., MAY 7, 1901.

NOTE: The system of fire control and direction proposed in this report is to be tested in Pensacola Harbor, Fla., and it has not been approved by the War Department.

Fort Wadsworth, N. Y.,
September 3, 1901.

* * * * *

The Board, having had under careful consideration the request of the Chief of Artillery that the Board submit some temporary scheme for Fire Direction and Fire Control that could be utilized at once for instruction, finally agreed upon the following:

PREAMBLE.

The question of Fire Control and Fire Direction is tactically and technically dependent upon the following propositions:

1st. The B. C. should fight his battery from the B. C. station, from which station he exercises Fire Direction.

2d. The discipline of the personnel and the service of the Battery should be under the charge of the Battery Officer assisted by the 1st Sergeant.

3d. Unless the B. C. station is so placed that the B. C. can communicate by word of mouth with the men at the guns, he cannot exercise disciplinary control of the personnel thereat. Therefore except in the case of a detached battery not a part of a Fire Command, the position of the B. C. station should be determined by tactical conditions of Fire Control, and not as a function of the position of the battery. Generally Fire Direction may be exercised at any distance from the battery, provided the field of view from the Observing Instrument covers the field of fire of the battery. There may be technical reasons which will limit the distance between the B. C. station and the Battery. The Board are as yet not prepared to pronounce positively upon this point until means shall have been furnished for further experiment.

4th. A single Fire Commander cannot exercise Fire Control over more than four batteries efficiently.

5th. The Station of the F. C. must be such as to admit of the most rapid means of communication with his Battery Commanders, and as close personal touch as possible.

Based upon the five propositions above stated, the Board have included the following in its scheme:

Each Fort to be divided into Fire Commands, depending upon the field of fire of the Batteries, and other local conditions.

Each Fire Command should consist of not more than four batteries.

The F. C. station and his B. C. stations should be grouped together and be known as the General Fire Control Station (G.F.C.S.) in such manner that the F. C. may be able to personally visit each station, under cover, and exercise Fire Control by word of mouth.

By this system the necessity for identification of targets by prediction, and the use of complicated methods of communication will be entirely eliminated; and the efficiency of the Fire Command will be materially increased.

At most Forts the Fort Commander will be the senior Fire Commander and will command the most important Fire Command.

At large Forts the Fort Commander may require a special station of observation in telephonic communication with the several F. C. stations. It is not expected that under the latter conditions the Fort Commander will exercise any fire control over a particular Fire Command, but a general fire control over the action.

A system of position finding based purely upon a vertical base will not meet the requirements of the service, in as much as it may often happen that the water-line of the vessel cannot be seen, due to the interference of other vessels, or from other causes. Therefore in all cases a depression system should be augmented by an auxiliary system with horizontal base.

A system based purely upon an horizontal base will also not meet the requirements, as no means has yet been devised whereby the target can with any certainty be indicated to the observer at the other end of the base line by azimuth instruments alone. Therefore whenever a horizontal system is used it must be combined with a depression system for the purpose of identification.

The Board therefore recommend two combined systems as follows:

THE D. P. F. SYSTEM.

In this system the location of targets, tracking of vessels, identification and prediction will ordinarily be done by means of the depression instruments. The auxiliary horizontal method to be used only when the work with the D.P.F. is impracticable.

THE H.P.F. SYSTEM.

This system is an Horizontal Base System using depression instruments at each end of the base-line, having an elevation of not less than 32 feet above mean high tide. The instruments will be used as depression position finders for the purpose of identification; and will be used as azimuth instruments for the purpose of location. Whenever the site does not admit of placing the G.F.C. Station at the above mentioned height above mean high tide, artificial structures must be erected therefor.

Whenever the use of two or more horizontal bases are required for the same battery, the B.C. Station should be at the intersection of such bases.

VIEWS OF THE BOARD WHICH MAY BE CHANGED AFTER MORE EXTENDED CONSIDERATION AND EXPERIMENT.

An emplacement 32 feet high or less above the natural site can be readily concealed, and will therefore not be a conspicuous target, and should be constructed for the G.F.C.S. at all sites under 32 feet above mean high water so as to give the instruments as high a command as possible, for the purpose of increasing the accuracy of identification and location. The idea of the Board is as follows: For the H.P.F. System on low sites advantage should always be taken of the possibility of constructing an emplacement 32 feet high for the purpose of obtaining greater command for the instruments. For the D.P.F. System the Board consider that a vertical base of 100 feet is the least with which accurate results may be obtained at 10000 or 12000 yards, and this should be the minimun base that should be used. By using an emplacement of 32 feet or less, the D.P.F. System can be used on natural sites of 68 feet above mean high water. Above 100 feet no emplacement is necessary.

The height of 32 feet has been adopted, first, because it is the minimum height of the interior crest above sea level used in the construction of gun emplacements, and therefore the G.F.C.S. emplacement, even without concealment, will afford no more conspicuous target than the batteries; second, because it is the minimum height from which identification can be done with any degree of certainty with depression instruments.

The greater rapidity of action of the D.P.F. System renders that system the more desirable of the two, and it should be preferred whenever the site is suitable. The D.P.F. System should not be installed where the height of the natural site is less than 68 feet above mean high water.

For all heights less than 68 feet the H.P.F. System should be installed. The instrument installed at the Primary Station should be the most improved D.P.F. instrument, in order that at short ranges, where rapid work is required, the depression method may be used, whenever the height is sufficient to insure accuracy.

A type "B" instrument will ordinarily suffice at the Secondary Station.

Based upon the above the Board submit a revision of Part V Coast Defense, Drill Regulations for Coast Artillery. Also a Tentative Method of Fire Control and Fire Direction. The Board do not feel prepared to recommend a Permanent Method until they have been able to carry on a more extended experimentation and a thorough test of the instruments proposed to be used; which of course cannot be done until at least one Fire Command has been completely equipped with the proposed apparatus.

The Board also suggest the trial of a proposed Observing Instrument to be known as the Combined Position Finder Type "A". This instrument to be essentially the same as the Lewis D.P.F., with the following modifications:

1st. The Minute Dial of the Relocating Arm should be attached to the outer end of said arm by means of a curved bracket (or other device) and should be geared with the circumference of the plate in the same manner as the Minute Dial of the instrument itself; in order to reduce the error due to back-lash, so that the two dials shall read accurately to one minute. The bracket must be long enough to admit of the full sweep of the arm for the maximum length of Spanner to be used.

2d. A second Relocating Arm to be attached to the instrument so as to relocate for the Secondary Station, Horizontal Base. This second Arm will be controlled by a Spanner having the scale length of the Horizontal Base, and be attached to the present traveling carriage so as to make a fixed angle with the present Spanner. This angle will be the difference between the azimuth of the base-line and the line between the instrument and the directing gun. This second Spanner should be made adjustable in precisely the same manner as the present Spanner.

As it will probably be impracticable to attach a minute dial to this second arm, in consequence of the necessity for all round work; it will be necessary to graduate the circle to read to minutes. A diagonal vernier system will probably be best suited for this purpose.

The Board wish to be understood as not recommending, as yet, any special form of instrument, but merely to indicate what is required. The proposed alterations to Type "A" instrument can readily be made to all the instruments at present in service at comparatively little cost. The Board, however, would not desire to express a positive opinion as to the adaptability of this device until an instrument has been altered and tried. This instrument would replace the present Type "A" D.P.F. and be used with both systems.

The Board recommend the following modifications and additions to the definitions contained in Part I, Drill Regulations Coast Artillery.

DEFINITIONS, ETC.

1st. All effects resulting from conditions requiring an additive correction either to the range, elevation or azimuths, shall be called Plus effects.

All effects resulting from conditions requiring a subtractive correction shall be called Minus effects. The soldier to be instructed to add for Plus conditions and to subtract for Minus conditions.

2d. All instruments, Graphic Charts or Tables used to indicate conditions requiring correction shall be constructed to indicate the same by the terms Plus or Minus.

3d. Allowance for deviation taken to the right shall be termed a Plus allowance, and to the left a Minus allowance, whether taken on the sight or the azimuth circle.

4th. Any arrangement of the sight which causes the muzzle of the gun to traverse to the right shall be called taking allowance right or plus. Any arrangement which causes the muzzle to traverse to the left shall be called taking allowance to the left or minus.

5th. All sights shall be so arranged that when the zero of the scale is to the right of the index, the allowance is right, and vice versa. In telescopic sights the vertical cross-hair shall be the index.

6th. The terms accelerating and retarding winds, and the term wind components, while retained for purposes of instruction in gunnery, shall be discarded as terms for practical use. A wind shall be considered as producing two ballistic effects, one increasing or decreasing the range and the other deviating the projectile to the right or left. These shall be termed plus or minus range conditions and plus or minus deviating conditions. They require a plus or minus range correction or a plus or minus deviating correction. The ballistic value of any particular wind is the value of these conditions expressed in miles per hour. Thus what is the ballistic value of a XI o'clock wind of 16 m.p.h.? Answer: 8 m.p.h. plus range, and 14 m.p.h. minus deviating·

7th. The line of fire is the prolongation of the axis of the bore of the gun as laid. The jump will then be defined as the angle included between the line of fire and the line of departure, and is to be subtracted from both the Q.E. and the S.E.

8th. The line from the gun to the target is called the Line of Direction and its angle of inclination with the horizon, the Angle of Inclination. Then the Q.E.=S.E.—Angle of Inclination.

The defense scheme proposed by the Board is based upon the following considerations:

The remarkable advance lately made in the manufacture of high explosives has materially altered the character of harbor defense. Not only has it been demonstrated that an high explosive of great power can readily be fired from powder guns, and that these explosives may be fired through armor plates of considerable thickness; but also that armor plates of 12" thickness can be entirely destroyed by the explosion of a charge upon their face, without any penetration. Both Maximite and Explosive "D" can readily be fired from a 12" B.L. Rifle using a torpedo shell, viz., 125 pounds Explosive "D" and 144 pounds of Maximite.

A 12" A.P. shot will hold 58 lbs. of Explosive "D".
A 12" Torpedo shell will hold 125 lbs. of Explosive "D".
A 12" A.P. shell will hold 58 lbs. of Explosive "D".

If Maximite is used the charge will be increased 15% in consequence of the difference of density.

12" torpedo shell loaded with 125 lbs. of Explosive "D" was fired against a 12" plate of hardened steel, with a remaining velocity equal to that which it would have had at a range of 3500 yards. The charge exploded on the face of the plate without penetration and the plate was utterly destroyed.

A 12" A.P. shell loaded with 58 lbs. of Explosive "D" was fired against a similar plate, and partially penetrated the plate which was utterly destroyed by the explosive.

No torpedo shells have been manufactured for the 8" and 10" guns and in fact the 12-inch torpedo shell is a mortar shell. The remarkable value of the new explosives will undoubtedly call for the construction of such projectiles; and we may therefore assume that in the future each gun will be supplied with the following ammunition.

A.P. shot loaded with a small charge of high explosive.

A.P. shell loaded with three times the quantity of high explosive.

Torpedo shell loaded with seven times the quantity of high explosive.

Common shell loaded with black powder. It is not at present deemed wise to use high explosive in a cast-iron shell.

It is manifest that the introduction of such a projectile as the torpedo shell must necessarily materially change the entire character and the possibilities of harbor defense.

We cannot as yet assume the introduction of this shell as official. It is, however, entirely proper to consider its possibilities in a defense scheme.

SELECTION AND INSTALLATION OF HORIZONTAL BASES.

In determining the length and direction of horizontal bases, the tactical and technical conditions involved in each polygon of attack, should be carefully studied; and a full report be made to the Chief of Artillery for his approval before the installation of the system.

As a rule base lines should not be less than 1000 yards long.

In considering the sector of attack of sea-coast batteries for the purpose of establishing base lines, the area which can be entered by torpedo boats only, as a rule, need not be considered.

When the sector of attack of any battery is greater than 120°, at least two base lines intersecting at the B.C. station will be installed

PART V.—COAST DEFENSE. (REVISED).

Coast defense comprises military and naval disposition and operations to resist an attack from the sea. The line of defense is the coast line, the important points of which are the harbors and cities.

The means employed are naval forces for general defense; troops to resist landings; and fortifications, with an artillery armament, mines and torpedoes, to avert a direct naval attack.

The fixed defenses of a harbor or contiguous portion of a coast line are distributed in groups covering the water and land approaches and provided with lines of communication to each other and to observing stations for the transmission of intelligence and with facilities for the movement and concentration of troops.

The fixed defenses of a harbor constitute a Coast Fortress, which may be defined as an area of land and sea, provided at certain important points or along tactically selected lines, with works of defense and with an artillery armament, partly fixed, partly movable.

This area is usually defined as the extent of land or water within range of its guns.

The fixed armament is mounted in forts or batteries.

Such defenses should provide cover for the stores and ammunition required for the service of the guns and accommodation for the garrison.

The guns forming the fixed armament are so disposed as to admit of concentration and distribution of fire upon the most important areas which they are assigned to defend.

In addition to the above, a fortress is supplied with a movable armament, designed for use either within the forts or batteries themselves, to intensify the fire at any important point, to defend mine fields, and to attack lightly armored or unarmored vessels; or outside the forts, frequently in temporary works, for similar purposes, and also to resist boat attacks, to protect landing places, and to supplement from selected positions the artillery defense of the land fronts.

The disposition of the movable armament of a district devolves upon the District Commander.

Whenever local conditions permit and require it, a system of sub-marine mines is maintained. These obstacles to the free passage of ships must be so placed that they are protected by artillery fire.

Only general principles for fire control, fire direction, drill, and organization are laid down. It rests with local commanders to apply these principles.

GENERAL DEFINITIONS.

Fort.—Under Army Regulations permanent posts are styled "Forts", the names being designated by the Secretary of War.

This term, in coast defense, has heretofore been applied to a permanent closed work.

Battery.—The term battery is used tactically to signify two or more guns (usually of the same caliber), their equipment and personnel organized into a unity of command for service. The term battery is also used to designate a number of guns in position for service, as well as the works in which the guns may be located. Wherever this term is used its meaning must be determined from the context.

The administrative unit of the personnel is called a Company.

Manning Detail.—This term, applied to any unit, means the personnel belonging to the same.

Manning Table.—A printed form on which to enter manning details. This form should always be kept up to date.

Fire Area.—The area of land or water, or both, which is effectually covered by the fire of the gun or other unit.

Electric Light Area.—The area of land or water effectively illumined by an electric light.

Target.—The object at which to aim, lay, or fire a gun or guns, as a boat, a ship, or other object, whether stationary or moving.

Displacement.—The distance in yards from the vertical axis of the position finder working a battery to the pivot of the directing gun or some fixed point in the battery.

Gun displacement.—The distance in yards from the pivot of any gun to the pivot of the directing gun or fixed point in the battery.

Gun differences for any gun are the range and azimuth corrections to be applied to the gun because of its "Gun displacement".

The *identification of a target* is any process whereby a target is indicated to a man at a distance so that he can identify it

Location of a target is the determination of its position, that is distance and azimuth, from any point.

Relocation of a target is any process whereby, having the location of the target from one point, its location from another may be obtained without further observation.

A spanner is a device used in position finding whereby a given distance can be spanned in a direction parallel to a given line.

Predicted point.—In vessel tracking it is that point which it is predicted that the target will reach at the expiration of a certain time.

Predicted firing.—Firing at a moving target by means of tracking and determining predicted points.

Set-back point.—When using predicted firing it is necessary to give the command *Fire* before the target reaches the predicted point so as to allow for the time of flight. The command *Fire* must be given as the target reaches a certain point, this point is called the *Set-back Point.*

Observing interval.—The time, in seconds, between two consecutive observations of the target in predicted firing.

Predicting interval.—The time interval, in minutes, used in determining the predicted point. The beginning of this interval is the time corresponding to the last plotted position.

Firing interval.—That interval which the battery commander selects for rate of fire.

The *field of fire* is that area over which the guns have command.

The *sector of attack* is that portion of the field of fire of any battery within which the enemy's vessels can enter.

The *polygon of attack* is that area covered by the sectors of attack of the various batteries considered.

GENERAL PRINCIPLES.

The application of artillery fire to the best effect of which it is capable requires that the guns be combined into batteries for fire direction, and the batteries into commands for fire control.

It is important that a clear distinction be drawn, and strictly maintained in practice, between *fire control* and *fire direction.*

Wherever the words *control, direct* and *direction* are used they will have technical significance as defined below.

FIRE CONTROL.

Fire control is the conducting of the tactical operations of any system of defense.

The exercise of fire control consists in—

(*a*) The determination, immediately on assuming command, of the general lines on which action is to be taken under the different conditions of attack ; and as far as possible of the details, including the establishment of the range zones in which the different classes of projectiles are to be used.

(*b*) Assigning to the different *batteries* the vessels they are to attack.

(*c*) Unless previously decided, giving the signal for different units to open fire.

(*d*) Ordering the concentration or distribution of fire on enemy's ships as circumstances may require.

(*e*) Decision as to the period at which fire is to cease.

(*f*) Insuring the proper record in the Fort Record Book of all permanent orders under the above heads.

FIRE DIRECTION.

Fire direction consists in the technical administration of fire under the orders of the officer exercising fire control.

The duties of fire direction consist in—

(*a*) Making certain that the orders relative to projectiles and charges are thoroughly understood and complied with.

(*b*) Identifying the particular targets assigned.

(*c*) Communicating the order and rate of fire.

(*d*) Observation and correction of fire.

(*e*) Change of target in compliance with superior order or on personal responsibility in case of unforeseen emergency.

(*f*) Maintenance of fire, and cessation when ordered.

The system of instruction, the method of application of technical data, the technical terms employed, and the entire work required of the personnel, should be simplified as much as possible, and should be rendered as nearly automatic as is found to be consistent with efficient work.

The system of fire direction prescribed in orders or regulations must be strictly adhered to as the habitual system. B.C's may however, under the supervision of the F.C., experiment with new appliances, provided it does not interfere with the habitual use of the prescribed system.

A full report of any system which tends to improve the methods authorized, will be forwarded, through the technical artillery channels, for file in the office of the Chief of Artillery, for use in preparing future drill regulations. No improvement or new device will be adopted at any post as the habitual drill except by authority of the Chief of Artillery.

FIRE DISCIPLINE.

The ultimate condition of the various units, resulting from organization, drill, and combined practice, which enables the commander to direct fire of any desired nature and rate upon any objective, and to change the objective at will, constitutes fire discipline.

This condition can be established only by training the commissioned and enlisted personnel in the correct performance of their duties in all positions in which they are likely to be placed in active service.

Constant drill and practice in preparation for service are essential in order that fire control and fire direction may be carried out.

DRILL.

The drills for the various guns of the armament will be based upon the following considerations:

Necessity for a simple and universal drill for guns of different types.

Separation of the different operations of serving the gun, and corresponding division of the detachment into details having, as far as possible, uniform duties, including ammunition supply.

Separation of the duties of giving elevation and giving training. Permanent details for the position finder and communications. Necessity for reducing to a constant interval the time of accurately serving the gun.

The drill in the service of the piece must be in accordance with the manual therefor, which allows a large latitude in minor details.

The adoption of new apparatus or new forms of carriage or breech action, will necessitate new methods of drill to suit particular cases.

Changes to meet such conditions must have the approval of the Fire Commander before being adopted for habitual use. B. C.s' may, however, experiment in order to determine the most efficient method of handling new devices.

ORGANIZATION.

Chain of command.—Fortress Commander, District Commander, Fort Commander, Fire Commander, Battery Commander.

The battery should be composed of guns of the same nature and with fire over practically the same water area. Their height above the sea level should be approximately the same; their position should admit of salvo fire; the front of the battery should be limited to the extent which, under local conditions, admits of thorough fire direction, and the possibility of accurate fire by salvos; the normal number of four guns should be adhered to as closely as possible.

The battery commander is in direct communication with his fire commander, from whom alone he receives orders, and to whom he is responsible for the fire direction and fire discipline of his command.

The station of the battery commander will be at the B.C. station. He should have stations on the right and left of the guns for his use when the B.C. station is out of action.

The battery commander is responsible for the condition of his armament and equipment, including ammunition supply, and the efficiency of his command.

The following are his duties in action:

He directs the fire of his guns on the target indicated to him by the fire commander; prescribes the order and rate of fire; and the projectile to be used.

The senior officer at the battery is responsible for the service of ammunition; that the prescribed projectile is used; the replacing of casualties; and the discipline of the men under his command.

Assignments at the guns and at the position finder will be permanent, the object being to have each man thorough in a definite duty.

Batteries will be organized into fire commands. The grouping of batteries into fire commands will depend on local conditions, and upon the number that can be efficiently controlled by one officer.

Fire Commander.—The officer having command of, and control over, a fire command is termed a "Fire Commander". He exercises fire control through his battery commanders.

He will be responsible to his immediate superior for the efficiency of his command.

A single fire commander cannot exercise fire control over more than four (4) batteries efficiently.

The station of F.C. must be such as to admit of the most rapid means of communication with his battery commanders, and as close personal touch as possible.

The F.C. station and his B.C. stations shall be grouped together, and be known as the General Fire Control Station (G.F.C.S.) in such manner that the F.C. may be able to personally visit each station under cover, and exercise fire control by word of mouth.

He exercises fire control from his station, which is a position finding station, and from which the whole of the water area and the approaches thereto can be fully observed ; it would be advantageous if this could be combined with a view over all the guns under his command.

He must have the necessary charts of the sea area and maps of the surrounding country, and all possible means of information which would enable him to judge of the character of the enemy directly he comes into view.

Accommodation should be provided in the fire commander's station for his staff ; consisting of an officer as assitant, the necessary observers, operators and orderlies.

The fire commander will retain in his hands the control of fire as long as possible, but a time will come undoubtedly in every action when all or a portion of this control will have to pass into the hands of the battery commanders. The possibility of so holding this control will depend almost entirely on the training of the officers and men under conditions approximating as closely as possible to those of actual service.

A Fort Command is the lowest unit of executive fire control, and is a tactical unit only. The administrative unit—the "Fort"—will be divided into Fire Commands, depending upon the field of fire of the batteries and other local conditions. Each fire command should consist of not more than four batteries.

At most forts the fort commander will be the senior fire commander and will command the most important fire command.

At large forts the fort commander may require a special station of observation in telephonic communication with the several F.C. stations.

It is not expected that, under the latter conditions, the fort commander will exercise any fire control over a particular fire command, but a general fire control over the action.

He must have a full knowledge of the nature and position of the mine fields and must also be aware generally of the disposition, etc., of the field forces protecting his flank or rear.

Forts and their commands are organized into districts.

A district will include one or more forts, with their fire commands, mine fields, and infantry positions. Their boundaries will be so traced as to include entire fire commands, all personnel and materiel following the guns.

Artillery being the main feature, the command should be vested in an artillery officer.

The district commander may be the senior fort commander; in any case, he will have such staff as may be required.

He should have an intimate knowledge of the land and sea area under his command, and of the surrounding country; he must have carefully considered, recorded, and practiced the mode in which he would employ his units to meet the different possible forms of attack.

He is responsible that all his units are in a fit state for defense as regards their armament, ammunition, and personnel, and as to the means of supplying the latter with proper accommodations, water, and food. He must specially see that the communications throughout his entire command are in good order.

Fortress Commander.—A fortress may consist of one or more districts. It should be commanded by an officer of rank commensurate with the importance of the place. His staff shall include such officers, non-commissioned officers and enlisted men as may be necessary.

Communications.—These are necessary to join the several links in the chain of command.

Communication will be established, from fortress to district commanders; from fire commanders to their respective battery commander stations; from each B.C. station to its guns.

Such an important part is played by communications that no pains should be spared in keeping them in perfect order; this can be done only by having them constantly cared for and operated. The lines should be so laid as to be secure from all interruption or interference. The terminals should be plainly lettered, and all information as to their use, and where the lines lead to, should be given. Speaking tubes or other means of oral communication should be established in the batteries as follows: Between the observing stations and gun emplacements, and from each gun platform to the cartridge and shell room and next gun platform.

SEARCH LIGHTS.

Search lights may be divided into three classes depending upon their use: Search lights proper, illuminating lights, and blinding lights.

Search Lights.—These lights are intended for searching the harbor for in-coming vessels; they should be kept continually in motion, and should be made to cover as great a field as possible. In order to obtain the best effect from these lights it is important that the observer should be under the light. The beam of light throws a reflected ray upon the water, parallel to itself, which gives sufficient illumination to detect the presence of any vessel and covers a great area. An observer above the beam cannot use this ray and must therefore depend upon the illuminating effect of the beam. It is therefore necessary that the observer should be below the beam, in order to utilize the light to its best advantage.

These lights should be under the command of an officer who should be in direct communication with the fort Commander.

Illuminating Lights.—These lights are intended to illuminate the vessel of the enemy. Each battery should have one light which should be under the control of the B.C. It should be placed in front of the battery and under the guns. For the most efficient work in this case the observer must be above the light. It is impossible to work through a beam, therefore all beams must be kept below the line of vision from the D.P.F.

Blinding Lights.—These are intended to blind the eyes of the pilots, and should be placed in prolongation of the channel as near as may be. They should be extremely powerful lights and should be under the command of a special officer. In addition to these, each fire commander should have a light to be used as he may think proper.

The F.C. lights and the illuminating lights should be under electrical control from the stations; the remaining lights may be fitted with hand control.

The lights should be so placed that, while they effectively illuminate the channel, the guns are left in the darkness.

GENERAL DEFENSE SCHEME.

A fleet will attack land defenses—

(*a*) By bombardment at long, medium or close ranges;

(*b*) By attacks on the mine fields and attempts to run by the batteries.

The best methods of meeting these forms of attacks will depend—

(*a*) Upon the strength of the ships, the power of their armament, and the speed.

(*b*) The position of the batteries and the power of their armament;

(*c*) The area and depth of water the fleet can make use of;

(*d*) And upon the form and depth of the channel.

Ships are not constructed to fight forts or land batteries. They are not a match at long ranges, because of the limited elevation that can be given their guns, the impracticability of their carrying mortars, and their unsteady platforms. They are not a match at close ranges, because modern high-power guns are more effective against armor than against earth or masonry, and because of the low platforms and small target. Ships will therefore attempt to run past; aiming to take the forts unawares or with as little notice as possible, and to pass by at the best speed consistent with safety.

They may make the attempt at night, or, closing in under cover of darkness, steam by at break of day.

The batteries can attack the decks by high-angle fire; the upper structure, unarmored, and lightly armored parts, and the belt and heavily armored parts, by direct fire.

This scheme is intended to cover only the general principles of the defense; all details for the batteries, submarine mines, or the lights, will be published in orders. Should it be found necessary to prescribe details which differ in principle from those prescribed in the defense scheme, the object and purpose of such orders should be clearly set forth so that each officer will have a clear understanding of the system of defense.

The field of fire will be divided into three zones. The deck piercing zone, the intermediate zone, and the armor piercing zone.

The D.P. zone is that zone in which it may be possible to pierce the armored decks of the enemy's vessel and explode a charge of high explosive within the vitals of the ship.

The Inter. zone, which lies between the D.P. zone and the A.P. zone, is that zone in which it will be generally impossible to penetrate either the deck or the armor, and where we must rely upon the terrific crushing effect of large charges of high explosive, or the destructive effect of common shell to render the ship *hors de combat*.

The A.P. zone is that space in which a properly directed A.P. shot will pierce the armor, or in which the armor may be readily destroyed by the effect of high explosives.

THE DECK PIERCING ZONE.

A 12" A.P. shell will penetrate 4" of steel, in a horizontal deck, at 12000 yards range. At 10000 yards the 10" A.P. shell will penetrate 2".8 and the 8" A.P. shell 2".4. Therefore at extreme ranges the A.P. shell should always be used with the hope of penetrating the armored deck and detonating a charge of high explosive within the vitals of the ship.

With an angle of fall of less than 10 degrees the projectile will not penetrate the deck but will glance off and probably explode above the deck. Therefore for ranges the angle of fall of which is less than 10 degrees the torpedo shell will do the greatest damage and should be preferred. The angle of fall therefore determines the interior limit of the D.P. zone.

The D.P. zone is independent of the character of the harbor. It is not understood that an armored deck can not be penetrated within this range, but it is not likely to be. The interior limit should take into consideration the command of the batteries.

THE INTERMEDIATE ZONE.

In the D.P. zone the objective is the vessel itself, an object is made to penetrate its vitals, and to destroy the boiler or engine, or to explode the magazine. This can be done only at long range, and therefore great care should be taken to obtain accuracy of fire at such ranges. In the intermediate zone the objective is the personnel and the armament. It is within this zone that the torpedo shell will undoubtedly do its maximum work. When we consider that a shell of this kind completely wrecked a 12" plate and its backing, simply by the force of explosion without any penetration it can readily be imagined what terrific havoc an explosion would produce in the upper works of a man of war.

THE ARMOR PIERCING ZONE.

The armor piercing zone is a function of the character of the harbor and dependent upon the lay of the channel. The penetration at any range is a function of the angle of fall, the normal penetration and the angle of incidence,—the latter is of course a function of the lay of the channel. The limit of the A.P. zone is computed upon the assumption that the vessel is in the center of the channel, and is taken at such a distance that the angle of incidence shall be less than 60 degrees, and the resulting penetration greater than 6". Of course the armor of the vessel may be penetrated at distances outside of the A.P. zone whenever it can be struck with the proper angle of incidence.

It is assumed however that an enemy's vessel will endeavor to so lay its course as to present the smallest target possible. The A.P. zone is that zone within which the armor may be penetrated, even under the most advantageous conditions for the enemy.

Within this zone, whenever it is deemed possible to penetrate the armor with an A.P. shell, as would be the case when attacking an armored cruiser, the shell should be preferred to the shot, in order to obtain the greater effect from the explosion ; in all cases where an A.P. shell will not penetrate the armor, A.P. shot should be used.

The remarkable effect produced by an A.P. shell against a 12″ plate will probably modify this rule.

At the longer ranges the capped projectiles should be preferred to the sharp pointed projectiles.

At unarmored vessels the torpedo or common shell should be used.

Whenever a vessel takes such a position that she can be struck with an angle of incidence of less than 60 degrees, an effort should be made to penetrate the armor, whether within or without the A.P. zone, especially if she is vulnerable to an A.P. shell.

DAY ATTACK.

Upon each B.C. chart the sector of fire of his battery will be indicated, and the three zones laid off. As soon as the B.C. has been assigned a target by the F. C. he will prepare for action and begin firing as soon as the vessel is within range (unless directed to the contrary), with A.P. shell, and continues his fire until the target enters the inter. zone, when he will immediately change to torpedo, or common shell, using the torpedo shell if he has it. If he knows his target to be an unarmored ship, he will begin firing with torpedo shell.

During this part of the action he makes up his mind as to the probable character of the vessel, thickness of armor, etc., and as soon as the target enters the A.P. zone, or before if in his judgment it is wise, he begins his battering attack with A.P. shot or shell, and continues the fire as long as the vessel is in range. Predicted fire will continue as long as practicable. At short ranges there will be no time for use of position finders. The range will be about all the information that can be furnished the guns. The ship in advance should be selected by preference. The heaviest fire should be brought to bear when the target is at shortest range and moving at right angles to the line of fire.

In conformity with the above principles, fixed trainings should be marked on the traverse circles of the guns and the corresponding ranges recorded in a convenient place.

RAPID FIRE BATTERIES.

The larger R.F. guns will open fire at the leading vessel unless otherwise directed, as soon as it is within range, using A.P. shell, and continue firing as long as possible, aiming at guns, ports, and other vulnerable parts. A.P. shot will not be used except when firing at battleships at short range. As soon as the vessel enters the A.P. zone, the R.F. guns will confine their fire to the upper works. The various groups of large R.F. guns may be specially directed to fire upon the second or third vessels instead of all being concentrated upon the leading vessel.

The smaller R.F. guns will be used to keep down the fire of the corresponding armament of the ships, intended to drive the men from the guns. A similar role will be assigned to the movable armament and the machine guns. Certain R.F. guns may be assigned to the attack of torpedo boats and the protection of the mine field. They should be so grouped as to effectively cover the mine field. As it is impossible to exercise the same control of the R.F. guns as in the case of heavy batteries, special instruction should be given to the commander of each group of R.F. guns so that a clear understanding should be had of the particular work assigned thereto. Each group of guns should be a separate command. There will be neither time nor necessity for superior command, nor for the use of range finding instruments. Ranging will be done with the guns or other means of rapid estimation.

R.F. batteries assigned to the attack of torpedo boats will open fire as soon as a boat is observed within the sector of fire and within range, without waiting for instructions from the F.C. This is necessary in consequence of the great speed of these vessels. R.F. guns will, however, not open fire on men-of-war unless directed to do so; or until the general signal for all batteries to commence firing is given.

Batteries assigned to the protection of the mine field will also open fire upon any vessel entering the field without waiting for command.

It may be deemed wise to group a certain number of R.F. guns with a particular heavy battery, in which case the R.F. guns so assigned will begin firing as soon as the vessel is in range, at the same target as the heavy battery with which they are grouped.

NIGHT ATTACK.

The fort commander will designate the search lights and the blinding lights, all of which will be under his control either directly or indirectly through officers detailed for the purpose.

Each B.C. of a heavy battery will have an illuminating light under his control.

At night all R.F. batteries, not especially assigned to the protection of the mine field, and not provided with independent search lights will be grouped with the heavy batteries depending upon their field of fire, and a proper distribution of fire over the entire polygon of fire.

The following rule is general: All heavy batteries will attack vessels illuminated by their own lights. All R.F. batteries (except as hereafter provided) will attack vessels illuminated by the lights to which they are assigned. Targets will be assigned by means of the lights, and whenever a target has been assigned to a particular light, all batteries assigned to that light will open fire as soon as the vessel is within range, and continue the same until otherwise directed, upon the target illuminated.

The night attack may be divided into three periods; The watching period, the torpedo boat attack, and the attack by the fleet.

The Watching Period.—In addition to any picket boats which may be stationed in the harbor, signal parties should be suitably located and arrangements be made with the local commercial telephone and telegraph companies for the use of their lines where necessary for thorough communication. Arrangements should also be made with local signal and life-saving stations to impart information as to the enemy obtained at such stations.

Officers and enlisted men should be assigned for duty to watch for pre-arranged signals from these points, as well as from the picket boats.

During the watching period all lights will be used for searching purposes, and all officers in charge of lights will be on duty as search officers. Whenever a vessel of the enemy is picked up by any light, such light will immediately cover and continue to follow until ordered to uncover.

As soon as an enemy's vessel is covered by one of the battery illuminating lights, the search lights proper will again take up the work of searching. The officer in charge of the blinding lights will direct one of his lights upon the vessel and attempt to blind out the pilot. Blinding work will as a rule be directed upon the leading vessel unless direction is given to the contrary.

The Torpedo Boat Attack.—The water area over which these boats can pass is very wide on account of their light draft. They have great speed, and are so colored as to be very inconspicuous. Their aim will be to pass the forts and destroy the shipping in the harbor.

As soon as the torpedo boat is covered by a light, all R.F. guns which can be brought to bear upon the vessel, will open fire without waiting for command ; the object being to crush out the vessel as quickly as possible. If two or more boats are illuminated at the same time, the R.F. batteries will open upon the boats which are illuminated by the lights to which they are assigned. Heavy batteries will not open upon torpedo boats unless ordered to do so.

Should heavy batteries be directed to open upon torpedo boats they will fire by piece and not by salvo.

The several B.C.'s of heavy batteries, and all officers in charge of position finders, will range the vessel and send the range to the R.F. batteries as soon as possible. R.F.G.C.'s will not wait for the range data but will estimate range and open fire as soon as possible.

The Attack by the Fleet.—As a general rule the attack will be directed upon the leading ship, and all batteries which can be brought to bear will be concentrated thereon. This, however, is entirely within the control of the fort commander. Targets will be located by lights, and will be assigned to the various batteries. The general principle of fire direction are the same as for the day attack, except that the fire of the small R.F. guns, and especially the machine guns will be directed mainly at the search lights of the enemy.

Such guns should be fitted with movable colored discs for use with the night sights when firing at search lights.

Search lights proper will continue searching the harbor.

All blinding lights will be concentrated upon the leading vessel unless ordered to the contrary.

Mine Fields.—So long as a properly planted and operated mine field is intact, ships cannot pass over it.

Mines can be removed or exploded by dragging, grappling with ordinary or explosive grapple, and by countermining.

Dragging and grappling are conducted from small boats specially fitted up for the purpose. Countermining is done by small vessels dropping charges of high explosives near the mines and then moving to a safe distance and firing the charges, or by throwing large charges of high explosives, the shots being placed successively so as to clear a channel through the mine fields.

These operations would be undertaken under cover of darkness or fog by small unarmored boats.

Floating defenses should also be provided, for on foggy nights the electric lights have little penetrative power, and small boats can evade the guns on shore.

Lights especially assigned for work over the mine field will not be diverted from that work, and will not attempt to cover any vessel not in the mine field, except during the watching period when all lights are search lights.

During the period of the watch by the fleet, all firing from heavy batteries will be by salvo.

BOMBARDMENT.

Should the fleet lay off and attempt to bombard, within the range of the guns of the defense, the F.C. will assign to each battery a particular target, and each B.C. will use his own judgment as to the fire direction of his battery, unless directed to the contrary by the fire commander.

MORTARS.

Mortars will be used at long and medium ranges. At long range the lighter shell will be used,—either the D. P. shell or the torpedo shell as the case may require. At the medium range the heavier projectiles will be used.

On the B. C.'s chart will be laid off the zones for heavy projectiles and light projectiles; also sub-zones showing the proper charge and the elevation required.

The use of high explosives in mortar shells will probably materially increase the value of mortar fire.

For a target at rest or in motion, the principles already laid down need no further amplification for their correct local application.

The general principles of mortar fire is to cover the area occupied by the enemy's fleet with a shower of shell.

The B. C. will determine the course of the target, lay his mortars for a particular area, and open fire so that his shells will fall upon this area, as the target is passing through. The general principles laid down for tracking and predicting will apply.

EMPLOYMENT OF MILITIA.

Where the militia are authorized to receive instruction in the service of coast artillery, the District commander, will, in his plan of defense for mobilization, provide for the distribution of the several organizations to the works and quarters to be allotted to their use while training.

These organizations will be trained with special reference to the works they may be called upon to man, and individual officers, non-commissioned officers, and men be allotted to certain specific duties, and be rigidly kept to these duties while training.

All officers for commands superior to the battery, staff officers, and all specialties, etc., will be detailed by the District or Fortress Commander.

The distribution of these organizations for the various "forts" will be recorded in the Fort Record Book, and on their arrival steps should be at once taken to perfect their training.

MANNING A FIRE COMMAND.

Organizations will be permanently assigned to the various units of the command.

A form will be provided, filled up, and kept posted, giving the officers, and non-commissioned officers, and men required to man the various units. A copy of this will be furnished the fire commander and extracts to the battery commanders.

At the signal "To Arms" the entire personnel concerned will at once run to their proper stations, and everything will be prepared for action with the greatest celerity.

At the signal for "Drill," the fire commander and his details will proceed to the fire commander's station; each battery will be formed in accordance with the manning table, the detachments and details verified and reported by their commanders; the battery commander will then proceed to his post; the other battery officers and the 1st. sergt. will proceed to the guns.

The gun commander marches his detachment to the rear of its emplacement, halts it, and indicates the gun detachment, the ammunition detachment, and other details. The ammunition sergeant posts his detachment, and immediately prepares for drill. The specials go to their posts. The gunner forms the gun detachment, "Calls Off," and commands STORES AND POSTS. At this command the detachment breaks ranks and each number goes for the particular implements assigned to his number, places them in proper position, and takes his post.

The G. C. then commands PREPARE FOR DRILL. At this command the gun is uncovered and prepared for drill. He then commands EXAMINE GUN, when a careful inspection of the gun, carriage, buffers, gears, &c., is made. The G. C. having received a report from the ammunition sergeant, that the ammunition service is in working order; and after seeing that all of the details are in their proper places, and understand their duties, makes his report to the officer in charge of his gun. The senior battery officer inspects the battery and finding everything ready for drill, reports the battery ready for drill to the battery commander. If anything is out of order so that it cannot be remedied at once, he immediately reports the facts to the battery commander. The B. C. then reports to his F. C.

In case of imminent danger, battery commanders will be kept in a state of preparedness, but this should be carried on in such a way as to entail as little hardship on the men as the case will admit of.

It is important that instruments should be set up ready for use, that all stores should be at the guns, that the telephones should be manned; and at night, guns loaded and trained and lights in place.

In case of sudden alarm, battery commanders will act without waiting for orders, in accordance with previous arrangements to meet the contingency.

FIGHTING A FIRE COMMAND.

The command being manned, is reported ready to the fort commander who gives such general instructions as are to govern.

The fire commander assigns the targets to his batteries, gives command to commence firing, observes the course of the engagement, changes the target when necessary, concentrates or distributes the fire, but should, as a rule, leave fire direction to the battery commanders, interfering only when necessary.

Should a battery position finder be put out of action, he may assign the battery to another position finder for target and range.

The target having been indicated by the fire commander, the battery commanders will cause it to be at once taken up by their observers and gun commanders; the latter will have their guns loaded and trained ahead of the target.

The range and azimuth for the directing gun is furnished by the position finder. To these will be applied the corrections for wind, atmosphere, speed, and direction of target, and observed fall of projectile, and the corrected range and azimuth communicated to the guns. The gun commanders will apply the necessary corrections for the gun displacement. In case of indirect laying, predictions for a constant interval will be made, corrected, communicated, and applied as above. The service predicting interval will be two minutes and may be sometimes one minute. For instruction it may be three minutes or more, but will be reduced to the service interval as soon as possible. Battery commanders will direct the kind, rate, and order of fire.

The salvo order of fire is in general the most effective. In this case, the battery will be fired on signal from, or electrically by the battery commander.

ORDER AND METHOD OF FIRE.

The salvo order of firing will be used in predicted firing, by heavy coast batteries, using Case III.

Fire by piece using Case II will be used only when it is impracticable to use predicted fire.

Case I will be used with R. F. guns only.

In mortar fire Case III will always be used.

DIRECTING GUN.

The right gun of the battery will always be assigned as the directing gun in order that the correction for azimuth shall always be "plus." When using the salvo order of fire, corrections for gun displacement will be made for azimuth only, the correction for range being neglected.

SERVICE OF FIRE CONTROL AND FIRE DIRECTION DEPRESSION POSITION FINDER SYSTEM OR D. P. F. SYSTEM.

Equipment of the B. C. Station.

One Depression Position Finder. Type "A".

One B. C. Observation Instrument.—The present form of Observation Instrument is useless for this purpose, and a Type "B" D. P. F., should be substituted therefor. Whatever form of instrument is used in the B. C. station, both instruments should be of the same kind so as to reduce the character of instruction which it is necessary to impart to the minimum. Thus, if the main observing instrument is a Lewis type "A" then the B. C. instrument should be a Lewis type "B", fitted with three vertical cross-hairs 15 minutes apart, and one horizontal cross-hair; also fitted with a device for clamping in azimuth.

Emergency Instruments.—The use of the type "B" instrument in the B. C. station does not in any way do away with the necessity for the usual emergency instruments at the battery.

Auxiliary apparatus:—

One Plotting Board,—see appendix.

One Auxiliary Scale,—see appendix.

Two Set Back Charts,—see appendix. One for service velocity, and one for practice velocity.

B. C. Table or Correction Chart,—see appendix.

One Time Interval Clock,—Similar to the one now in use, preferably mechanical rather than electrical in its action. It must, however, be in electrical connection with, and serve as a master clock for, an electrical time interval bell in the secondary station.

One Wind Clock and Vane,—The apparatus now in use is not satisfactory. A method by which the velocity and azimuth of the wind can be obtained at the highest point free from local interference and can be communicated automatically to each B. C. Station, is necessary.

One Aneroid Barometer.
One Thermometer, Fahr.
One B C. Difference Chart,—when necessary.
One Secondary Station Difference Chart,—when necessary.
Search Light Controller.
Pencils, Slates or Blackboard, etc.
List of distances and azimuths to permanent points.
Electric Firing Device.

EQUIPMENT OF THE SECONDARY STATION.

This station will be equipped with a type "B" Observing Instrument, fitted with three vertical cross-hairs 15 minutes apart, and one horizontal cross-hair; also with a device for clamping in azimuth.

THE GENERAL FIRE CONTROL STATION.

This station consists of the F. C. Station, the B. C. Stations, and a switch board room.

The Fire Commander's Station is fitted with a D. P. F., type "A", plotting board, and speaking tubes connected with each B. C. Station for use if necessary.

The switch-board room must be situated in a place of absolute protection. The purpose of this room is as follows: All electric wires enter this room and are distributed to the various B. C. Stations by means of the switch-board. A certain number of spare wires should be laid in all conduits for use in case of emergency. Let us assume that the various batteries are lettered.

The station of Battery "A" is destroyed, the B. C. probably killed. The F. C. turns over the command of Battery "A" to the B. C. of Battery "B". The operator switches the "A" wires in series with the wires of station "B", and the B. C. of Battery "B" directs the fire of the two batteries as one, from a single directing gun. The gun commanders of Battery "A" will then use difference charts computed for the directing gun of Battery "B". Should the conduit of any battery be destroyed, the operator switches the communicating apparatus of that station on to a spare cable.

THE GENERAL SECONDARY STATION. (G. S. STATION.)

For each G. F. C. station there will be a General Secondary Station at the other end of the horizontal base. When practicable the different instruments of this station will be oriented with, and be the same distance apart as the instruments of the G. F. C. S. so that the same length of base line may be used by all. This arrangement will make plotting boards interchangeable.

DATUM POINTS.

For the construction and the method of adjusting upon these points, see appendix.

COMMUNICATIONS.

Telephonic and telautographic communication between the B. C. station and the battery; also between the B. C. station and the secondary station. Visual system for communicating technical data simultaneously to each gun from the B. C. station; and azimuths from the secondary station to the B. C. station. Electric buzzer, and single stroke bell in B. C. station actuated from secondary station.

MANNING DETAIL.

F. C. Station.—The F. C. and an officer to act as his adjutant. Observer, plotter, operators.

Switch-board Room,—operator and assistant.

B. C. Stations,—Battery Commander,
  Observer,
  Chief of station, who is the senior member of the detail, excluding the observer.
  The detail, consisting of:
    Plotter and first assistant,
    Reader, who is second assistant plotter when H. P. F. is used,
    Two computors,
    As many operators for communicating system as may be necessary,
    Search light operator,
    The Chief of station will be assigned to whichever of these positions he is most competent to fill.
    General duties.

Fire Commander.—No post assigned. He will, however, use the F. C. station for observation. His special duties are prescribed under Fire Control.

Adjutant.—His post is the F. C. station; his duties are prescribed by the F. C.

Battery Commander.—The post of the B. C. is the B. C. station, from which he will exercise Fire Direction of his battery. He observes the fire and orders the necessary correction in the fire of his guns or mortars. He changes the target on orders from the

F. C. or on his own responsibility in case of unforeseen emergency. His special duties are prescribed under Fire Direction.

The Observer.—He is responsible for the care and preservation of both observing instruments. His post is at his own instrument. He is responsible to, and takes orders from, the B. C. only. He proceeds directly to the station, inspects and adjusts both instruments, reports to the B. C. and takes his post.

The Chief of Station.—He commands the detail (exclusive of the observer).. He calls the roll, marches the detail to the station, inspects all of the auxiliary apparatus, reports the result of his inspection to the B. C. and takes his post. Each member of his detail is responsible that the instrument or apparatus to which he is assigned is ready for work.

The Reader.—The special function of this member of the detail is to call off the range and azimuth as given by the D. P. F. His post is on the right side of the observer; he assists the observer in adjusting. When the horizontal method is in use, he is the Second Assistant Plotter, and his duties are prescribed under the H. P. F. system.

The Plotter.—Post at the plotting board. When the Depression Method is in use, he plots, determines the predicted point, and the set back point, as prescribed under Fire Direction, D. P. F.

SYSTEM.

The 1st. Assistant Plotter.—Assists the Plotter.

The Computers.—The two computers determine the ballistic conditions and make the necessary computations therefor, using the apparatus provided. The division of duties will be determined by the B. C.

Communication.—Each operator controls the particular line to which he is assigned.

Search Light.—The Search Light Operator, at night, has charge of the search light controller, which he operates under the direction of the B. C.

FIRE CONTROL, G. F. C. S. SYSTEM.

The general principles of Fire Control are prescribed in Coast Defense.

The Fire Commander, on assuming command, determines the general method to be employed in action, or drill, depending upon the local conditions of the field of fire of his command; decides upon the zones in which the different kinds of ammunition are to be used; and sees that these zones are properly entered upon the plotting boards; lays out a plan of action, or instruction, and sees that the B. C.'s thoroughly understand the same; causes all orientations to be tested, and sees that datum points are properly "located," and that such location is posted in a conspicuous place in each B. C. station.

Identification of targets and other orders are given by word of mouth to the several battery commanders.

Where no G. F. C. station has been established, orders and instructions must be given by telephonic or telautographic methods.

Identification of targets will be done as follows:

IDENTIFICATION OF TARGETS.

The target having been selected by the F. C., he causes its position to be predicted,—one minute interval,— two observations. (See Fire Direction). He then sends to the battery, by the system of communication provided, the command "identify target," giving the azimuth and range of the predicted point.

The B. C. determines the azimuth and range of the predicted point from his own station, by the difference chart or other means of relocation, and causes the observer's instrument to be set for the same.

As the target approaches the predicted point the command READY is sent from the F. C. station to the B. C. station. As the target crosses the intersection of the cross-hairs of the F. C. instrument the command NOW is sent to the B. C. station; at which command the target should be on the cross-hairs of the B. C. Instrument and easily identified.

F. C. COMMUNICATION.

One of the most difficult problems of communication is that from the F. C. to the several B. C. stations. The F. C. must be able to communicate to each station separately, to all simultaneously, or to any particular number of stations at the same time. The following is probably the simplest method:

In the F. C. station there is a separate line of communication to each battery, each having its own operator. These operators are designated by the names of their respective batteries. When the command is CLIFTON BATTERY,—IDENTIFY TARGET, the Clifton operator sends the message. Should the command be CLIFTON AND RAVENNA, the two operators designated send the message. should the command be ALL BATTERIES, then all the operators send the message simultaneously.

These names are used for the purpose of illustration. With telephones this might cause confusion; with telautographs or visual means of communication, no confusion would be produced.

The chief objection to this system of Fire Control is the time required to identify and assign targets to each battery. It will take over two minutes to assign each target. With four batteries and four targets it would require ten minutes to make all assignments.

Most of these difficulties, both as to communication and assignment are eliminated by the G. F. C. S. system.

FIRE DIRECTION.

Before entering upon a general description of the system of Fire Direction, the method of prediction is described below.

Prediction.—The target having been identified, the B. C. having satisfied himself that the observer has the right target, he commands PREDICT. The observer follows the target, and at the bell signal stops following until the reader has called off first the azimuth and then the range. The observer then continues to follow, carefully taking the azimuth and range at each bell signal until the plotter calls out STOP.

Note: The observer does not attempt, while following, to keep both the vertical and horizontal hairs on the target; this would lead to error in plotting. He follows the target carefully with the vertical hair, keeping it slightly in advance of the bow of the target.

A little practice will enable him to keep the vertical hair just such a distance in advance of the target, that at the first stroke of the time interval bell, he can stop following and the hair will be on the bow at the last stroke. Extreme accuracy in taking azimuth is not important; should the vertical hair be slightly off the bow at the last stroke, the error in plotting will not be material. Exact water lining is, however, extremely important, and a slight error materially effects the plotting.

The observer pays but little attention to his horizontal hair while following, merely turning the handle occasionally so as to keep the target above the hair. As soon as he hears the first of the bell, he stops following and gives all of his attention to water-lining so that at the last stroke he will have the horizontal hair exactly on the water-line of the bow of the target.

In order to save time the observer turns the handle of the relocating arm once after each bell signal; to the left if the target is coming in and to the right if it is going out. After the plotter calls STOP he turns the handle a number of times; three for each minute of predicting interval. If the instrumental and the relocating range scales were set the same when the tracking began, this method would bring the relocator range scale to about the predicted distance and save time in relocating. If the two were not together atthe start, this method would not be used, but the observer should take advantage of the time intervals ta gain distance on his relocator making one turn in the required direction immediately after each bell; this could be done while the reader is calling off while the instrument is at rest. A little practice will enable him to save considerable time in this way. He will also have considerable time while the plotter is determining the predicted point to make several turns.

Horizontal Method.—When this system is in use the observer follows in azimuth only. See H. P. F. system. The reader acts as 1st Asst. Plotter.

Plotting by Polar Co-ordinates.—The plotter sets the range arm at the azimuth called off by the reader, and as soon as he receives the range, plots the position of the target. This he continues to do until he has obtained four points sensibly in a straight line, and in which he feels sufficient confidence to predict, when he calls STOP. He then applies the auxiliary scale and plots the predicted point, and calls off its azimuth and range to the observer.

As soon as the azimuth and range of the predicted point have been determined, the plotter will obtain the set-back point by means of the set-back scale.

The service predicting interval will be two minutes, and may sometimes be one minute. The first instruction will however be at three minute interval.

The Auxilary Scale.—This scale is used to predict the position of a moving target at the end of one, two or three minutes after the last observation has been taken and plotted. Several forms have been devised; a very simple one is described in the appendix.

Let A, B, C, D, represent four plotted positions of a moving target, at twenty second interval; the target travelling in the direction A–D.

The A–D is the distance and direction traveled in one minute. Lay the auxiliary scale on these four points so that the zero is at D; measure the distance D–A by the scale "A" and lay off by the scale "B" the corresponding distance in the direction the target is moving; mark this "P."

Then will P be the point the target will reach three minutes after leaving D. This is a prediction with three minute interval.

For a two minute prediction, perform the same operation placing the zero at A instead of D.

For a one minute prediction place the zero at D and use only the scale "A."

For the purpose of identification, prediction is made in the F. C. station at one minute interval from two observations as follows: Let A–B be the plotted position of the two observations. Lay the scale with the zero at "B"; measure the B–A by scale "A"; lay off the corresponding distance by the scale "B" in the direction the target is moving, and mark the point "P"; then as A–B is the distance passed over in twenty seconds, B–P will be the distance passed over in one minute.

GENERAL SYSTEM OF FIRE DIRECTION.

The B. C. commands PREPARE FOR ACTION (OR DRILL.) The clock is started and everything made ready for action or drill. The target having been identified, the B. C. commands AT TWO (OR THREE) MINUTES INTERVAL—PREDICT. The prediction is made as already explained. As soon as the azimuth and range of the predicted point is determined, the observer sets his instrument on the point and relocates for the directing gun, and the reader calls off "Azimuth from Gun," "Range from Gun."

At the command PREPARE FOR ACTION (OR DRILL) the computers determine the atmospheric conditions, and obtain the wind velocity. When the reader calls off the azimuth and range from the gun, the computers write it down and determine the wind effects from the dial for the given azimuth. The computers make the necessary computation, and call off the corrected range and azimuth, which is sent to the battery operator.

While these computations are being made, the plotter determines the set-back point by means of the set-back chart, locates the point, and as soon as the corrected data is called off, gives the range and azimuth to the set-back point. The B. C. gives the commands READY and FIRE from his own instrument. Preferably the firing should be done by electricity by the B. C.

While the prediction is being made the B. C. sends to the battery commander his orders as to the rate and order of fire.

Note on Prediction.—It is not necessary that the predicted point should be plotted at the end of any particular second of time, provided sufficient time is given to load and lay. Should it be found that the predicted point will fall outside of the channei, and that the target will probably turn before reaching such point, the B. C. will select a probable point in the channel, from which the set-back point will be laid off. This point wlll be used instead of that plotted on the stright line.

SECOND METHOD.

In the majority of harbors where the channels are narrow, and where vessels must necessarily move along certain general lines, the previous method will ordinarily be sufficient, and should be used when practicable. In other places the following method will be used:

After the set-back point has been determined, the B. C. observing instrument alone will be set on that point, and the observer's instrument will continue to follow. The plotter will plot the position of the target each twenty seconds and will report to the B. C. if the target is changing direction. The B. C. will, if necessary, lay upon a new point, and cause a new set-back to be taken. In sending a new azimuth and range to the guns, the azimuth and range will be sent, and in no case will corrections be sent to be made at the guns. In determining the new point sufficient time must be allowed for relaying the gun.

TRACKING DRILL.

For the purpose of instruction in Fire Direction two systems of tracking drill will be practiced; Preliminary and Service Tracking Drill.

Both of these systems involve fire direction with simulated firing.

Preliminary Tracking Drill.—In this drill no allowance is made for atmospheric conditions, wind or drift. The guns are laid directly on the predicted point. The B. C. observing instrument is also laid directly on the point, and the command FIRE is given as the target passes the cross-hairs. The gunner is at the sight, and as soon as the target enters the field of his instrument he follows it with his movable cross-hair. At the command FIRE he ceases to follow and sends the deviation of his sight to the B. C. station. The observer follows the target and determines its azimuth and range at the command FIRE. He then relocates and determines its range and azimuth from the directing gun. By comparing the observations at the gun, (assuming that the range of the shot will be the theoretical range for the elevation), with the position of the target at the command FIRE, the accuracy of laying and predicting can be determined.

Service Tracking Drill.—In this drill all allowances are made. The command FIRE is given as the target passes the set-back point. The position of the target is taken both at the gun and by the observer, not at the command FIRE but at a certain time thereafter equal to the time of flight for the predicted range. In comparing for determining the accuracy of laying and prediction, all allowances must be taken into consideration.

Auxiliary H. P. F. System.—When this system is in use the method of tracking prescribed in the H. P. F. system will be used.

COMMANDS.

For the purpose of uniformity the following commands will be used:

All (*or such*) *batteries*—IDENTIFY TARGET. *Ready;* NOW.

All (*or such*) *batteries*—COMMENCE FIRING AT (SUCH) RANGE, or COMMENCE FIRING WHEN IN RANGE.

All (*or such*) *batteries*—FIRE AT WILL.

All (*or such*) *batteries*—CEASE FIRING.

All (*or such*) *lights*—COVER. FOLLOW.

All (*or such*) *lights*—UNCOVER.

PREPARE TO CONCENTRATE.

These commands may be given by word of mouth, by telephonic or telautographic communications, or by means of speaking tubes, according to circumstances.

FIRE CONTROL AT NIGHT.

Fire control at night differs from that during the day only in the manner of identifying targets. The F. C. may assign targets to the various B. C.'s by word of mouth or in the following manner. At the command IDENTIFY TARGETS, all beams are thrown upwards except the F. C. light, which is brought to bear upon the selected target, and the command is given *All* (*or such*) *lights*—COVER. Lights are known by the names of their batteries. The indicated lights immediately cover the target illuminated by the F. C. light. As soon as the F. C. ascertains that the proper target is covered he commands FOLLOW; when all of the indicated lights follow the target although the F. C. light may be immediately withdrawn. The command is then COMMENCE FIRING, &c.

The rule of night firing is that all batteries fire upon the target illuminated by their own lights, and continue the work until the command CEASE FIRING is given, or the target passes out of range.

Except in case of emergency, the B. C. cannot select his own target, unless the command FIRE AT WILL has been given.

R. F. GUNS.

For the rule governing the fire of R. F. guns see "Defense Scheme."

UNDER HORIZONTAL METHOD.

The principle is the same as for the depression method except as to the manner of insuring that the observer at the secondary station properly identifies the light of his own battery.

Each battery has a signal letter. When it is necessary to use the horizontal method, the secondary station is notified and the battery light signals the battery letter, being careful not to lose the target in so doing.

NOTES.

In plotting by the depression method, the bow of the target should be used in water-lining as the foam about the bow gives a very distinct back ground, and the wave effect is not so noticeable as along the side of the target. The command FIRE should, however, be given as the smoke-stack passes the set-back point. This allows one-half of the target's length to counteract any error in predicting.

Two set-back charts should be furnished for each B. C. station, one constructed for the service velocity, and one for the practice velocity.

Several forms have been devised; a simple one is described in the appendix.

Arrangements should be made so that the F. C. can fire all of the guns of his fire command simultaneously by electricity should he so desire, for the purpose of massing fire upon a particular target.

Each battery should be furnished with difference charts so computed that any battery can be laid from the directing gun of any other battery in the fire command. Frequent practice should be had in changing the fire direction of the various batteries, so that the G. C. will be prepared for an emergency, should any B. C. station be destroyed.

AT THE GUNS.

The principal things to be kept in mind at the guns are as follows:

Rapidity in loading.

Rapidity and accuracy in serving and changing ammunition.

Rapidity and accuracy in the use of the difference chart.

Extreme accuracy in laying the gun in azimuth and range.

HORIZONTAL BASE POSITION FINDER SYSTEM OR H. P. F. SYSTEM.

The following subjects pertaining to this system are the same as for the D. P. F. System, where they are given in full:

Equipment of G. F. C. Station and G. S. Station.
Equipment of B. C. Station.
Equipment of Secondary Station.
Datum Points (see appendix).
Communications.
Manning Details.

Fire Control, including
  G. F. C. System,
  Identification of targets,
  F. C. Communications,
  At night.

Battery Commander.—The post of the B. C. is his B. C. Station, from which point he exercises fire direction so long as this station is in action. It is important that the B. C. should get his observers on the target with the least practicable delay and to ensure himself that no mistake has been made by the observer at the secondary station as to the proper target. When the target has been assigned by the F. C., and identified by the B. C., the latter causes the observer at his station to ascertain its azimuth and range, by means of which and the plotting board, the azimuth and range of the target from the secondary station are determined and sent thereto, together with a short description of the target and the particular point on which observations are to be made.

The observers being ready, he gives the order to start the clock.

He observes the fire and orders necessary corrections. He fires the guns or mortars of his battery from his station from the F. C. or as otherwise directed. He changes the target on orders from the F. C. or on his own responsibility in case of unforeseen emergency.

FIRE DIRECTION.

Identification.—Identification is done by the Depression Method.

The B. C. having identified the target, places the observer's instrument upon it and commands PREDICT The observer then takes the instrument and a one minute prediction is made by polar co-ordinates, two observations. (See Prediction D. P. F. System.)

The azimuth and range of the predicted point hauing been thus determined, it is relocated for the Secondary station, either by plotting board, difference chart, or other system of relocation.

The relocated azimuth and range are sent to the Secondary station together with a short description of the target. The secondary observer sets his instrument to these data, and at the command NOW endeavors to identify the target. At low sites the target may not be on the vertical cross-hair of his instrument, but will be near the horizontal cross-hair either within or just without the field of view of his instrument.

A little practice should enable him to identify the target with ease.

Prediction.—The target having been identified the B. C. commands, *At (so many) minutes interval,* PREDICT. The clock is started and the kind, rate and order of fire sent to the battery. The observers follow the target, stop at the bell signal, call off the azimuth, continue to follow, take the azimuth at each bell signal and call it off as before.

In following the target the observers endeavor to keep the vertical cross-hair on the indicated part of the target. The azimuth called off at the Secondary station is sent to the B. C. station by the proper operator and there announced. As a rule the B. C. station azimuth will be plotted first by the first assistant, who will call out SET when the range arm is set to azimuth, and will keep it set till the second assistant has set his arm to azimuth from Secondary station, and the plotter has marked the position of the target at the intersection of the edges of the two arms. When four consecutively observed positions have thus been plotted and the plotter is satisfied that he can predict by them, he applies the auxiliary scale (see appendix) and determines and marks the predicted point. (Note.—The service predicting interval is two minutes and may sometimes be one minute. For instruction it may be three minutes or more but will be reduced to the service interval as soon as possible.)

The plotter next applies the proper spanner (see appendix) and relocates for the directing gun, calling off "Range from gun (so many yards)," the first assistant calls off "Azimuth from gun (so and so)."

These data are corrected for abnormal conditions by the computers and the corrected data sent to the guns.

The plotter now determines and marks the set-back point (see appendix) determines and calls off "Range to set-back point (so many) yards."

The first assistant reads and calls off "Azimuth (so and so.)"

The B. C.'s instrument is set accordingly and clamped. The second assistant, by means of his plotting arm, or by the difference chart for Secondary station, ascertains the range and azimuth of the set-back point from the Secondary station, to which the data are sent and the instrument thereat set and clamped. Each observer ceases to follow the target on hearing announced the data for the set-back point. Any observations they may have taken up to this time will be noted and plotted as soon as possible for the information of the B. C. As soon as the target enters the field of either instrument, the observer thereat waterlines, without moving his instrument in azimuth. As the bow of the target passes either the right or left hair of the secondary instrument, the observer starts his buzzer. When and so long as any part of the target is on the center hair he sounds the bell. As the stern passes the opposite side hair the observer stops the buzzer.

The B. C. fires as the target passes his center hair if the buzzer is ringing and if he believes the target to be approximately at the range.

He can judge of this by noting whether the target entered the firing field (the space between the right and left cross-hairs) of his instrument before it did that of the secondary instrument, or vice versa.

By watching the target as it crosses the firing field and the course of the target he can readily judge of the position of the target as to its probable range.

The B. C. commands READY and FIRE at his own instrument.

Should it be found that the predicted point will fall outside of the channel, and that the target will probably change its course before reaching that point, the B. C. will select and mark on the plotting board a probable point in the channel over which the target will pass.

There will arise frequent occasions for the exercise of judgment by the B. C. as to a probable predicted point different from the plotted point. In all cases his selected point becomes the predicted point for which all data is determined, and to which the guns are laid.

The commands READY and FIRE will be sent to the Secondary station. Observations will be resumed at the next bell signal.

TRACKING DRILL IN CONNECTION WITH THE GUNS.

Preliminary.—No allowance is made for abnormal conditions. The gun is laid on the predicted point. The gunner at his telescopic sight follows the target with the vertical cross-hair and reads the scale at the command FIRE, given when the target is on the vertical hair of the B. C.'s instrument, set to the predicted point.

This reading, plus or minus, is sent to the B. C. station, by means of which the predicted point and the position of the target plotted from observations taken at the base end stations at the command FIRE, the error in azimuth in laying the gun and the error of prediction can be determined.

Service.—In this drill abnormal conditions are allowed for.

The command FIRE is given when the target reaches the set-back point, and the signal "Now" thereafter at the termination of the time of flight interval. At this signal the gunner, as before explained takes the reading, and the observers the azimuth of the target. In comparing for errors the allowance for abnormal conditions must be considered.

COMMANDS.

For the purpose of uniformity the following commands will be used, communicated by word of mouth, by voice tubes, or by other means.

All (*or such*) *batteries*—IDENTIFY TARGET. *Ready;* NOW.
All (*or such*) *batteries*—COMMENCE FIRING AT (SUCH) RANGE.
All (*or such*) *batteries*—FIRE AT WILL.
All (*or such*) *batteries*—CEASE FIRING.
All (*or such*) *lights*—COVER. FOLLOW.
All (*or such*) *lights*—UNCOVER.
PREPARE TO CONCENTRATE.

DIFFERENCE CHARTS.

Each battery should have difference charts so computed that any battery can be laid from the directing gun of any other battery in the Fire Command in case of emergency.

Frequent practice should be had in changing fire direction of the various batteries. Spanners should also be at hand for the same purpose.

Referring to drawing (see plate I), 7 is the top of the table embracing one, two, three or four quadrants, depending upon the polygon of fire of the particular locality. The top of the table is of wood on proper supports.

1, is the range arm, german silver; $\frac{1}{20}$ in. thick, one and $\frac{1}{2}$ in. wide; graduated on right edge to read 10, 50, and 100 yds., each 100 yads. numbered up to 12,000 yds.

2, is the secondary arm, same as range arm, right edge beveled.

3, is the auxiliary arm, german silver.

4, is a cross piece with holes for adjusting to bases of different lengths. german silver.

5, is the base arm, german silver.

8, is the azimuth circle, graduated as shown at H, so that by means of the scale shown at I on the arm 1 or 3 azimuths to within one minute may be set off.—German silver.

6, is a piece connecting opposite sides of the azimuth arc. This piece is below table top. See K.—German silver.

The arms are secured as shown at 9 and 10, and at I and M.

The base arm Q–Q can be revolved about its pivot at 10 and clamped at the base arm to azimuth of base. 9 and 9′ are movable along Q–Q for adjustment to length of base. (These pivots represent the Secondary station, and 10 the B. C. station.)

When the Secondary station is to be changed, as from 9 to 9′, remove the arm 2 (the Secondary arm) and place it upon the pivot at 9′, at the same time remove the cross piece (4) and connect with 2, by means of the proper hole.

On the plotting board should be represented the D. P., A. P., and intermediate zones, and in case of mortars the powder zones, all for service conditions. The following should also appear on the board, viz:

Main and other channels.

The 24, 20, 16, 12 and 8 foot sounding curves, easily followed and distinguished.

The shore and coast lines.

Islands, banks, light houses, bouys, beacons, datum and other fixed points that may aid in fire direction.

A Secondary Base, as nearly as possible perpendicular to the Primary Base, will be necessary for locating targets near the prolongation of the latter base. The intersection of these bases should be at the B. C. station, so as to have a common range arm.

Draw a line on plotting board from B. C. station to a point on the azimuth arc distant from Primary Base 30 degrees. Do this on each side.

Whenever a target is about to cross this line (in plotting) change observations to the Secondary Base, notifying the observers at both Secondary Stations.

THE SPANNER.

Plot with great accuracy on a piece of thin sheet brass or other suitable metal, the position of the F. C., B. C. and Secondary stations; the gun pintles and other desired points, to a scale of 300 yards to the inch.

At each point drill a small hole just large enough to admit the sharp point of a pencil. For the F. C. Spanner, fasten a needle point at the F. C. point, allowing it to project below about $\frac{1}{16}$ of an inch.

For the B. C. Spanner do the same at the B. C. point. Trim the plate to a rectangular shape to include all the holes and have one edge pass close to the needle point. This edge is the orienting edge and should have any azimuth convenient for orienting the spanner on the plotting board. Secure a small handle to the spanner over or near the needle point. See plate II.

Draw with care, on the plotting board, parallel lines about 2 inches apart having the same azimuth as the orienting edge of the Spanner.

To use the Spanner.—Stick the needle point into the plotting board at the plotted point; turn it about this point till its position is reversed in azimuth and the orienting edge is parallel to the parallel lines on the plotting board. With a sharp pencil make a mark on the plotting board through such holes as represent the points for which relocation is desired. Remove the spanner, bring the range arm to each point in turn and read the range and azimuth.

THE AUXILIARY SCALE.

(Plate III.)

On the fiducial side of this scale is the measuring scale A, which is graduated the same as the range scale, 300 yds. to the inch. Just back of this is the multiplying scale B, which is graduated 100 yds. to the inch. The zero of both scales coincide, and is in the center, and the scales read both ways. It will thus be seen that scale B is three times scale A, and if a line is measured by A and laid off on B, the line laid off will be three times as long as the line measured when the same reading is used with both scales.

This scale is used to predict the position of a moving target at the end of one, two or three minutes after the last observation of the target has been taken and plotted. The method is indicated in fig. 2, plate III.

Let ABCD represent the plotted positions of a moving target, the result of observations by the D. P. F. at twenty second intervals. Then AD is the direction and distance traveled by the target during one minute.

Let P repsesent the predicted point which the target will reach at the expiration of any given interval of time, which interval should not exceed three minutes, so as to avoid, if possible, any change of direction or speed on the part of the target. The time will be computed from the last observation, the point D.

Three minute prediction.—Lay the scale on the points so that the zero is at D. Measure DA on the scale A and lay off the same indicated distance on the scale B. This will give the point P which the target will reach three minutes after passing the point D.

Two minute prediction.—Lay the scale so that the zero will be on A, instead of on D. Measure AD on scale A and lay off by scale B, as before, in the direction the target is moving; and the point P will be the point the target will reach two minutes after passing D.

One minute predictions.—Place the zero on D and use only the scale A. Measure DA and lay off the same distance in the opposite direction. This will give the point where the target will be one minute after passing D.

SET-BACK CHART.

Plate IV shows method of constructing this chart.

Plate V shows completed chart.

Plate VI shows method of using chart.

To construct the chart (see Plate IV), lay off the square ABCD 9 inches square, and construct the scale on AB and AD as indicated. The maximum of 900 yds. per minute is taken as that which will more than suffice for the most rapid torpedo boat.

Now lay off in pencil the line EF one inch above and parallel to DC.

This line EF is the axis of times of flight, and is used only for purposes of construction. The scale is two seconds to the inch.

Determine from the B. C. table the time of flight for a range of 1000 yds., and lay this time off on EF from E; in the plate this point is marked (a); draw the 1000 yd. line from the origin (A) so that it will pass through (a), if prolonged; the line, however, ceases at the margin and is marked 1000 as indicated. In a similar manner lay of the range lines and continue until the chart is complete, as shown in Plate V, after which the line EF may be erased. These lines may first be drawn in pencil from A to the line EF and afterwards be inked only to the margin of the square.

It will be found convenient to construct these charts on cross-section paper 10 to the inch.

The principle upon which this chart is based is as follows: The set-back in yards for a range having a time of flight of twenty seconds will be exactly the distance the target has traveled during twenty seconds, and the set-back for any other range will be directly proportional to the time of flight for such range. By making the square 9 inches on a side, and laying off the time line EF one inch above the upper line of the square and graduating it at two seconds to the inch, it follows that the diagonal of the square AC will, if produced, pass through the twenty-seconds graduation. The diagonal is therefore the range line for a range having a time of flight of twenty seconds; the other range lines are inserted so that the distance measured on the set-back scale will be proportional to the times of flight.

Plate V shows a completed chart for a 10 in. B. L. rifle for a m. v. of 2025 f. s.

The set-back chart is used with a T-square, which is shown in position in Plate VI. This scale is graduated the same as the set-back scale, on the line AB.

The distance traveled by the target during one minute is measured upon the plotting board by the auxiliary scale A, and the T-square is set to correspond; in the drawing this is shown as 500 yds. per minute.

If, now, the range is known, the set-back can be read from the T-square by following the range line down to the square. Thus, the set-back for 6500 yds. is 100 yds.

CORRECTION TABLE.

The chief difficulty in obtaining accurate and rapid work in computing is found to be due to the necessity for making multiplications.

This difficulty has been obviated by constructing a correction table (see Plate VII). This consists in computing the corrections for all data, and arranging it in a table. It will be noted that the correction for any condition can be obtained from this table by simple addition. Thus, a correction for a wind 24 miles per hour is obtained by adding the correction for a 20 mile wind to that for a 4 mile wind; and so for any other data.

This table is merely an amplification of the B. C. Table.

* * * * * *

(SGD.) JOHN L. TIERNON,
Lieut. Col. Art'y. Corps,
President.

(SGD.) SEDGWICK PRATT,
Major Art'y. Corps,
Member.

(SGD.) G. N. WHISTLER,
Captain Art'y. Corps,
Member.

(SGD.) GEO. W. GATCHELL,
Captain Art'y. Corps,
Recorder.

APPENDIX.

The following forms of auxiliary apparatus are deemed suitable for use with the D. P. F. and H. P. F. systems, and indicate the general principles of construction and method of use.

Officers should, however, be encouraged to submit any improvements to the same which they may consider as more suitable for the purpose.

330-1

PLATE I.

PLOT

SECTION

F TABLE AND

RCLE

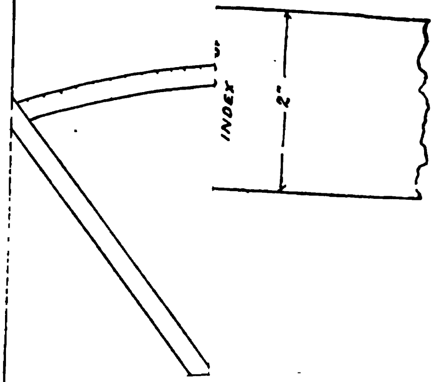


PLATE II.

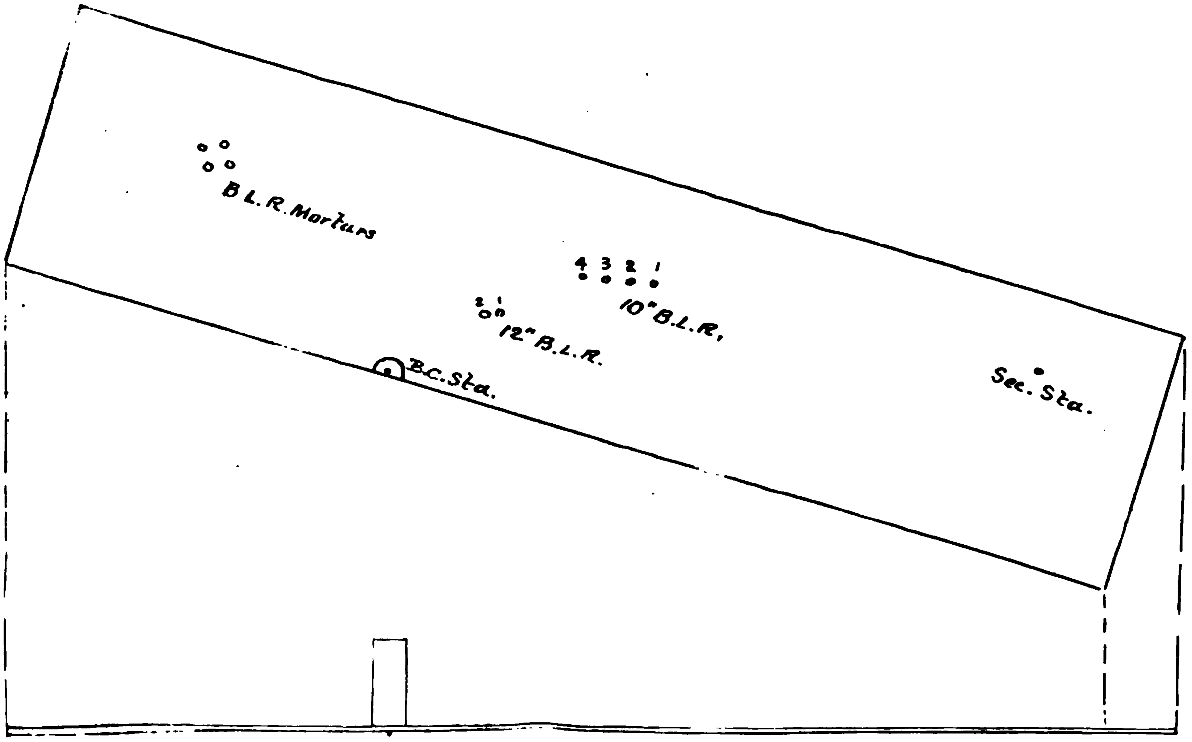


PLATE II.

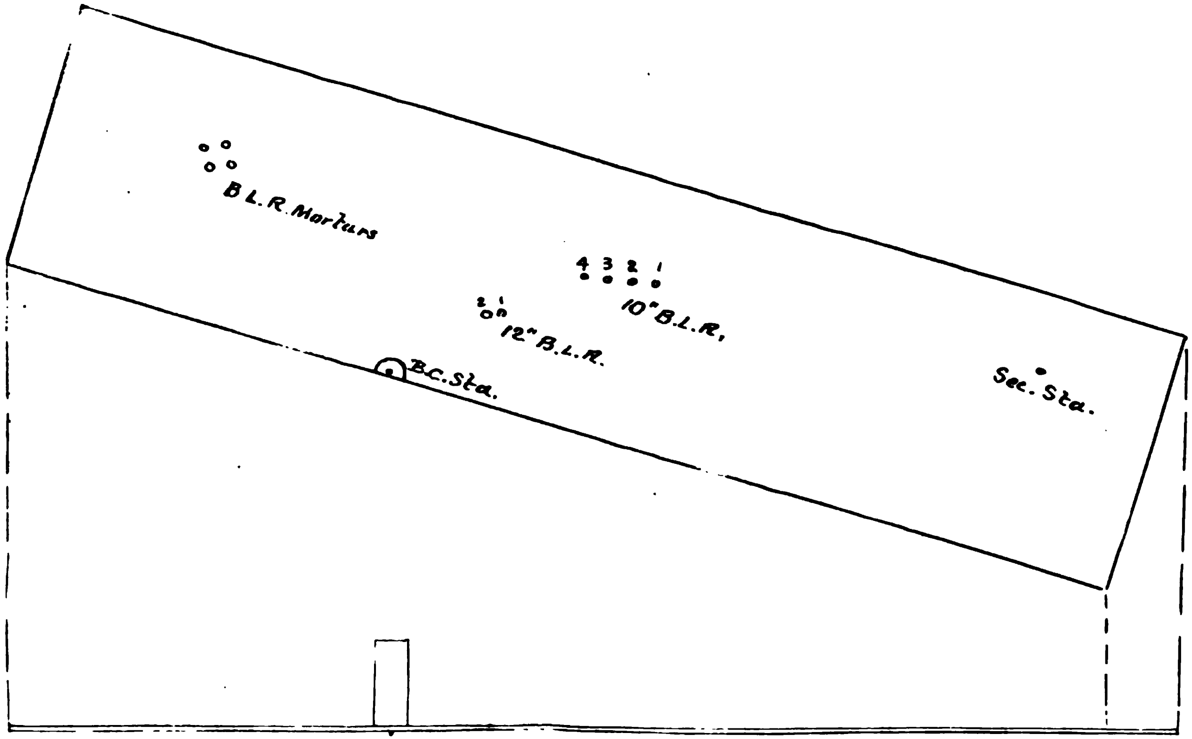
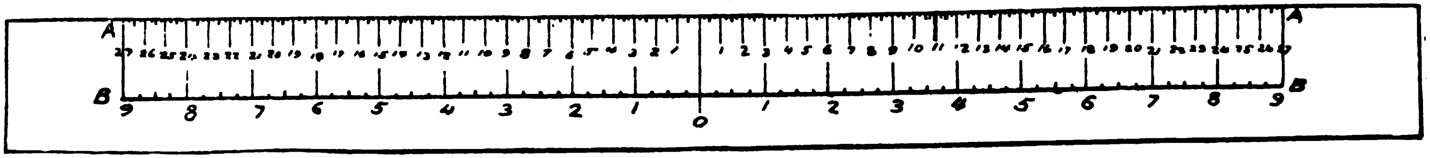


PLATE III.

Fig. 1.

Scale ½



Auxilliary Scale

Fig. 2.

Method of Prediction

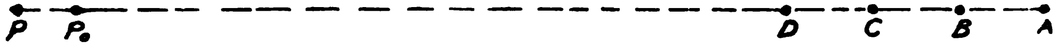


PLATE IV.

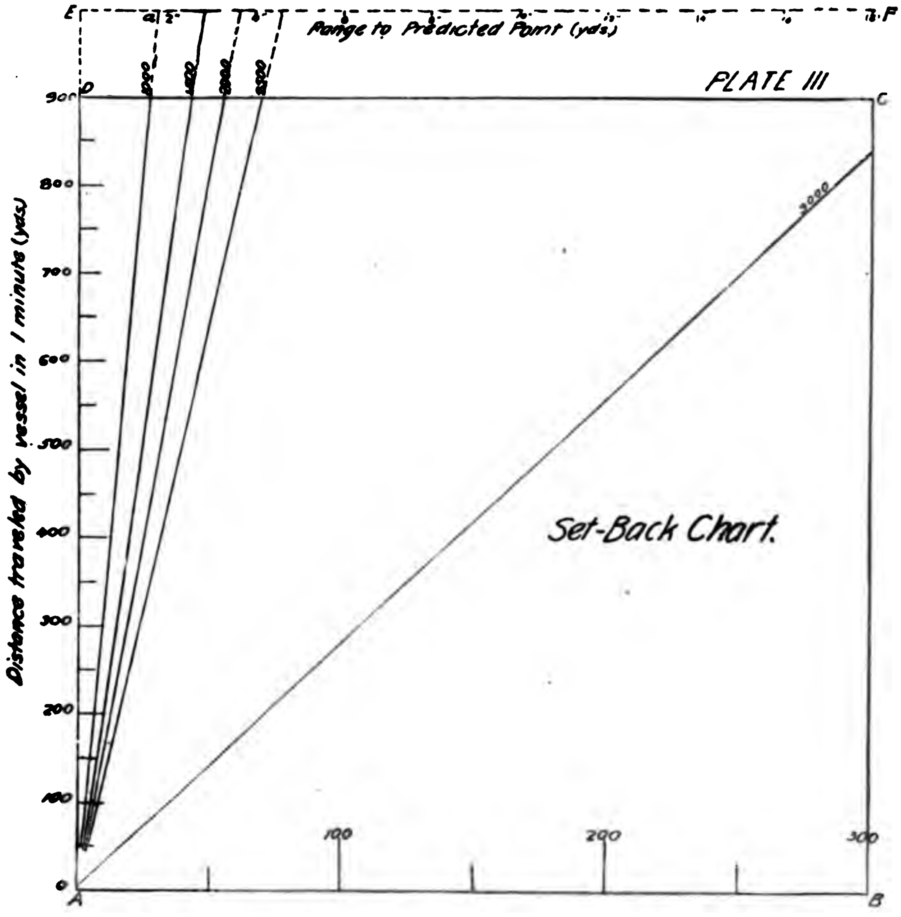

E
F
Range to Predicted Point (yds)
D
PLATE III
C
Distance traveled by vessel in 1 minute (yds)
900
800
700
600
500
400
300
200
100
0
A
B
100
200
300
3000
Set-Back Chart.

PLATE V.

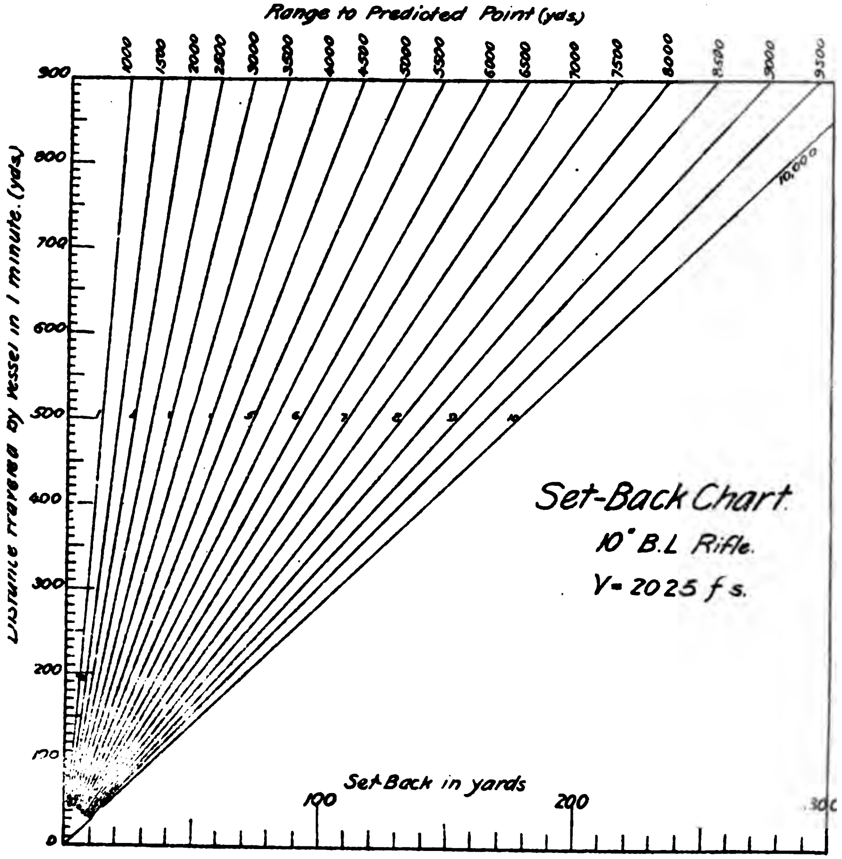
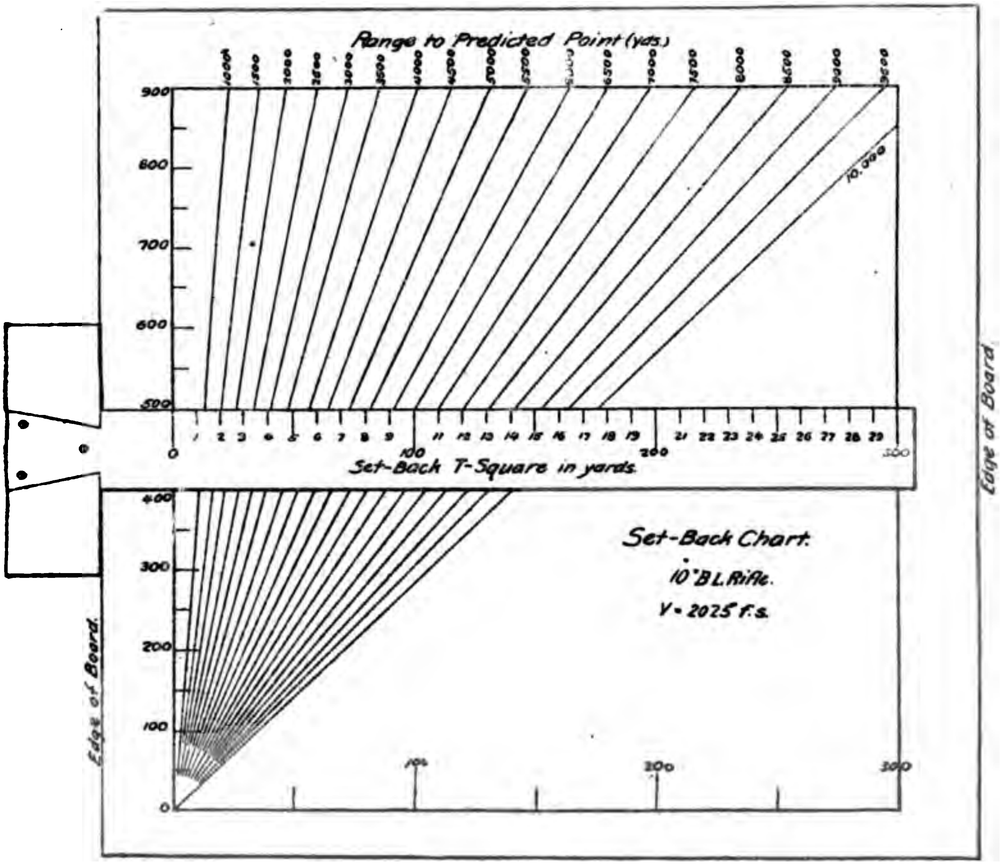

Range to Predicted Point (yds.)
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10,000
Distance traveled by vessel in 1 minute. (yds.)
900
800
700
600
500
400
300
200
100
0
1
5
6
7
8
9
10
Set-Back Chart
10" B.L. Rifle.
V = 2025 f s.
Set-Back in yards
100
200
300

PLATE VI.


Range to Predicted Point (yds.)
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
10,000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 100 11 12 13 14 15 16 17 18 19 200 21 22 23 24 25 26 27 28 29 300
Set-Back T-Square in yards
100
200
300
Edge of Board
Edge of Board
Set-Back Chart.
10" B.L. Rifle.
V = 2025 f.s.

MUZZLE VELOCITY = 2025 F.S.

	ATMO							DEFLECTION CORRECTIONS (MINUTES)													
RANGE	PER						MINUS SIGN	WIND - MILES PER HOUR													
	1/4	1/2	3/4	1	2	3	DRIFT	1	2	3	4	5	6	7	8	9	10	20	30	40	50
10000	9	19	28	37	74	111	18	1	2	3	3	4	5	6	7	8	9	17	36	34	43
9800	9	18	27	36	72	107	17	1	2	3	3	4	5	6	7	8	8	17	25	34	42
9600	9	17	26	34	69	103	17	1	2	2	3	4	5	6	7	7	8	16	25	33	41
9400	9	17	25	33	66	99	16	1	2	2	3	4	5	6	6	7	8	16	24	32	40
9200	8	16	24	32	63	95	16	1	2	2	3	4	5	5	6	7	8	16	23	31	39
9000	8	15	23	30	61	90	15	1	2	2	3	4	5	5	6	7	8	15	23	30	38
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
8800	7	14	22	29	58	87	14	1	1	2	3	4	4	5	6	7	7	14	22	30	37
8600	7	14	21	28	56	84	14	1	1	2	3	4	4	5	6	6	7	14	22	29	36
8400	7	13	20	27	53	80	13	1	1	2	3	4	4	5	6	6	7	14	21	28	35
8200	6	13	19	26	51	77	13	1	1	2	3	3	4	5	5	6	7	14	20	27	34
8000	6	12	18	24	49	73	12	1	1	2	3	3	4	5	5	6	7	13	20	26	33
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
7800	6	12	17	23	47	70	12	1	1	2	3	3	4	4	5	6	6	13	19	26	32
7600	6	11	17	22	44	67	11	1	1	2	2	3	4	4	5	6	6	12	19	25	31
7400	6	11	16	21	42	63	11	1	1	2	2	3	4	4	5	5	6	12	18	24	30
7200	5	10	15	20	40	60	10	1	1	2	2	3	4	4	5	5	6	12	17	23	28
7000	5	10	14	19	38	57	10	1	1	2	2	3	3	4	4	5	6	11	17	22	28
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
6800	5	9	14	18	36	5	10	1	1	2	2	3	3	4	4	5	5	11	16	22	27
6600	4	9	13	17	34	5	9	1	1	2	2	3	3	4	4	5	5	10	16	21	26
6400	4	8	12	16	33	4	9	1	1	2	2	3	3	3	4	5	5	10	16	20	25
6200	4	8	12	15	31	4	8	0	1	1	2	2	3	3	4	4	5	10	15	20	25
6000	4	7	11	15	29	4	8	0	1	1	2	2	3	3	4	4	5	9	14	18	24
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
5800	3	7	10	14	27	4	8	0	1	1	3	2	3	3	4	4	5	9	14	18	23
5600	3	6	10	13	26	3	7	0	1	1	2	2	3	3	3	4	4	8	13	17	22
5400	3	6	8	12	24	3	7	0	1	1	2	2	3	3	3	4	4	8	13	17	21
5200	3	6	8	11	22	3	7	0	1	1	2	2	2	3	3	4	4	8	12	16	20
5000	3	5	8	10	21	3	6	0	1	1	2	2	2	3	3	3	4	8	11	14	19
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
4800	2	5	7	10	19	2	6	0	1	1	1	2	2	3	3	3	4	7	11	15	19
4600	2	4	7	9	18	2	6	0	1	1	1	2	2	2	3	3	4	7	11	14	18
4400	2	4	6	8	16	2	5	0	1	1	1	2	2	2	3	3	3	7	10	13	17
4200	2	4	6	7	15	2	5	0	1	1	1	2	2	2	3	3	3	6	10	13	16
4000	2	3	5	7	13	2	5	0	1	1	1	2	2	2	2	3	3	6	9	12	15
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
3800	2	3	5	6	12	1	4	0	1	1	1	1	2	2	2	3	3	6	9	12	15
3600	2	3	5	6	11	1	4	0	1	1	1	1	2	2	2	2	3	5	8	11	14
3400	1	3	4	5	10	1	4	0	1	1	1	1	2	2	2	2	3	5	8	10	13
3200	1	2	3	4	9	1	4	0	0	1	1	1	1	2	2	2	2	5	7	9	12
3000	1	2	3	4	8	1	3	0	0	1	1	1	1	2	2	2	2	4	7	9	11
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
2800	1	2	3	4	7	1	3	0	0	1	1	1	1	1	2	2	2	4	6	8	10
2600	1	2	2	3	6		3	0	0	1	1	1	1	1	1	2	2	4	5	7	9
2400	1	1	2	3	6		3	0	0	1	1	1	1	1	1	2	2	3	5	7	9
2200	1	1	2	2	5		3	0	0	0	1	1	1	1	1	1	2	3	4	6	8
2000	1	1	2	2	4		2	0	0	0	1	1	1	1	1	1	1	3	4	6	7
	1/4	1/2	3/4	1	2	3		1	2	3	4	5	6	7	8	9	10	20	30	40	50
1800	0	1	1	2	3		2	0	0	0	1	1	1	1	1	1	1	3	4	5	7
1600	0	1	1	1	3		2	0	0	0	0	1	1	1	1	1	1	2	3	4	6
1400	0	1	1	1	2		2	0	0	0	0	1	1	1	1	1	1	2	3	4	5
1200	0	0	1	1	2		1	0	0	0	0	0	0	1	1	1	1	2	2	3	4
1000	0	0	0	1	1		1	0	0	0	0	0	0	0	1	1	1	1	2	3	4

DATUM POINTS.

These are constructed at long, medium and short range as follows:

A wooden pile (about 12" in diameter) is driven at the selected point; around this is placed an iron cylinder (about two feet in diameter) as a guard against the teredo; the space between the pile and cylinder is filled with cement or concrete to make the structure solid.

The top is then cut off at three feet above highest water. The exact level of the top above mean low water must be determined.

To make a complete adjustment:

Set the telescope to the range of the datum point and the tide scale to the height of the telescope above the top of the datum point; bring the horizontal cross-hair to the top of the datum point by the refraction screw; then, by means of the tide screw, bring the hair to the water line of the datum point. The instrument will then be adjusted for tide and refraction.

It is important that accurate adjustment should be made as often as possible. During tracking drill this should be done detween each tracking. During fire control drill and in action it should be done as often as practicable. At the complete adjustment by any observer, the method prescribed above should be strictly followed. In subsequent adjustments, if the error is found to be slight, and the atmosphere remains apparently the same, it is undoubtedly due to the tide, and a correction by the tide scale should be made. If, however, the error is apparently great, or if there is a manifest change in atmospheric conditions, a complete adjustment should be made.

In many in struments it will be found that changing the focus of the instrument raises or lowers the cross-hairs; this is due to mechanical error in construction, or in assembling the telescope, and should be corrected as much as possible. It is manifest that under such conditions, two observers requiring a different focus, would obtain different ranges to the same object, unless the instrument was adjusted for each observer. Experience has shown that this defect may cause a variation of more than 100 yards in a distance of 5000 yards, To counteract this error the following rule must be strictly adhered to. Whenever an observer is changed the instrument must invariably be re-adjusted. Should an observer be disabled during tracking, in which case there would be no time for re-adjustment, the new observer should not change the focus of the instrument, unless absolutely necessary. It is better to use an instrument correctly adjusted for tide and refraction with indistinct vision, than an instrument not so adjusted with clear vision. Method for quick adjustment.—Sight on the water-line of the datum point and read the range; if the error is slight, set to correct range and adjust by means of the tide scale. A new observer may adjust in a similar manner using the refraction screw instead of the tide scale.

This is based upon the assumption that the old observer left the instrument in adjustment, and that the error is due to focussing.

If the error is great the complete adjustment must be made. In all cases the observer must focus his instrument before making any adjustment.

PLOTTING BOARD.

(Scale 300 yards to one inch.)

The Plotting Board here described is a modification of the re-plotting device designed by the Board on Regulation of Coast Artillery Fire. (See Drill Regulations for Coast Artillery, p. 60.)

TO FIRE AT WILL.

When a target passes within a range of 2500 yards the B. C. may command FIRE AT WILL, when the control of each piece passes into the hands of the gun commander, under the supervision of the battery officers. The fire will be "by piece" using case II.

The gunner immediately mounts the sighting platform, identifies the target, and determines its approximate speed, then sets his sight for speed. Drift and all other allowances are ignored.

Method of identification.—During the previous firing the gunner should have been at a point where he could have observed the fire of his gun; he therefore knows the target, and the identification merely consists in picking it out and laying his gun upon it.

To obtain approximate speed.—Lay the gun (sight at zero), slightly in advance of the target; as the bow reaches the vertical cross-hair follow with the movable hair while counting one, two, three, four, five, at second intervals. Note how many minutes of arc the cross-hair has passed over during that interval of time, and set the vertical cross-hair the same number of minutes of arc on the opposite side of the zero, and the sight is set for speed. This based upon the fact that the time of flight for 2500 yards is about four (4) seconds for all heavy sea coast guns. This is simple "rule of thumb" that can readily be remembered, and is sufficiently accurate for all practical purposes.

To range.—The only data which can be sent to the guns at this time is range. This can be sent from the type "(A", but is preferably obtained from the emergency instruments at the battery, thus saving the time required to relocate for the directing gun.

The range of the target is called off by an assistant observer at equicrescent intervals, say every 25 yards, thus 2400; 2375; 2350; 2325; 2300; etc.

To aim.—The gunner is directed to aim at a certain part of the target. It is his duty to keep the gun aimed on a point slightly in advance of the point indicated. This distance is a function of the time required to take cover and fire; it must be determined by practice at drill. It also depends upon whether the gun is traversed by hand or by power.

To fire.—The gun commander directs the gun to be set for the elevation corresponding to a certain range, and commands FIRE as the target arrives at that range.

Example.—As soon as the gun is loaded and in battery, the G. C. hears the range 2375 called off; he directs the gun to be elevated for 2300 yards. He then notes raughly (say by counting) the time intervals between 2350 and 2325, and gives the command FIRE as the 2300 is called off. Say that he knows by practice that it requires five seconds to take cover and fire, and that he has counted twelve seconds between the ranges called off. He would then command TAKE COVER at the seventh count after the 2325 has been called off, to allow the men to get out of the way, and FIRE as the range 2300 is called.

It is manifest that when hand power is used the gun will cease to move when the command TAKE COVER is given; therefore the gunner must aim a sufficient distance in advance to allow for the five seconds so consumed.

At drill.—In practicing this method at drill the gunner counts the time of flight after the command FIRE is given and reports the point on the target covered by the sight when this time has expired. In counting time of flight for this drill, it will be sufficiently accurate to take the time as 4″ from 2500 to 2000 yards; 3″ from 2000 to 1500 yards; 2″ from 1500 to 1000 yards; and 1″ within this range.

NOTE.—Discussion of foregoing in the Journal is invited. Ed.

PROFESSIONAL NOTES.

ARTILLERY MATERIAL.

Armor and Ordnance.

To summarise, the armored ship is more in evidence than ever She will be protected at the water line by a broad belt starting well below water, where it meets the edge of the sloping armor deck and extending several feet above the water. The thickness of the belt may possibly be increased, but it seems probable that the increased resistance required to withstand the improvements in guns will take the form of thickening the slope of the armor deck.

Above the belt an armored box battery will occupy the midship part of the ship, and above this again, at the four corners of the battery, will be the principal secondary guns in turrets, the main armament being installed in double turrets or barbettes, as has now been for some time the case.

The same arrangement seems likely to be followed for cruisers as well as for battleships.

With the adoption of turrets and box batteries the casemate will disappear.

The thickening of the armor of the main barbettes is most necessary.

The increase of the caliber of the secondary guns of battleships and first-class cruisers is imperative; much of the top hamper encumbering the upper decks of armored ships will have to go; also, possibly, the funnels will have to be lowered in action.—*Brassey's Naval Annual* 1902.

Armor Plates and Projectiles.

The year 1901 has not been notable as regards the manufacture of new types of armor. The Krupp process holds the field, and has been adopted by almost all nations, including England, America, Russia, Germany, Japan, Italy, in which latter country the Turni works have lately paid a composition to Krupp, whose system has also been imported into France. It has certainly been declared in that country that the French type plates were found to be greatly superior to those made in France by the Krupp process; but the fact remains that the Russians, when buying plates in France, absolutely insisted on the Krupp process being used. The Russians have wide opportunities of learning which process is the best—they have excellent steel works of their own, they deal largely in America and to the same extent with Germany, and their testimony to the value of the Krupp process is one that must carry weight with all thoughtful men.

The Krupp process ("K. C.") is at its best for plates from 6 inch to 9 inch in thickness. It is much to be disired that the high resistance of the plates of medium thickness should, as experience is gained, be extended to thicker and thinner ones. But this has not been the case. The 11½-inch Carnegie plate, attacked by the 12-inch gun in competition with Gathman, was barely up to the average of plates of this thickness tried some years ago, and although some half-dozen trials of plates under 6 inch have been recorded, none of them showed any specially high resisting powers. Nor have there been many trials of very special interest apart from those in connection with the Gathman gun. The fact is, when a process is thoroughly established, as is the case with the Krupp process at present, the trials are almost all reception trials of plates and projectiles. In the former the plate has usually some 20 per cent. higher resisting power than the shot has piercing capacity, so the latter is readily smashed up, whilst in the other case the projectile is altogether an overmatch for the plate, which it gets through easily.

* * * * *

Except in the Mikasa, the big guns are now comparatively unprotected against their fellows, whilst the secondary guns fare extremely well. The only exception to the latter is when the secondary guns are attacked by the 9.2-inch of the King Edward or the 8-inch of the Georgia. Guns of this size will therefore be probably adopted in all new ships. The 7-inch and 7.5-inch, with 7-inch and 8-inch penetration respectively, will also supercede the 6-inch. Moreover, the reintroduction of, say, 15-inch barbette plates seems more than likely. There is no justification for the present fashion of denuding barbettes to favor other parts of the ship. It will probably be found possible to make barbettes smaller, which would allow some thickening of the armor without increasing the weight.

Though there is no sound reason for the reduction of the thickness of barbette armor, there is a plausible reason that may have carried weight with the authorities in various countries. The piercing power of guns is usually assessed at the muzzle. This would be most practical if ships were going to engage as in Nelson's day. But under existing conditions, where the torpedo prohibits an approach to 2000 yards, the system is absurd and most misleading, being grossly unfair to the heavy gun. At the muzzle the penetrating power of the 6-inch is half that of the 12-inch; but at 3000 yards the 6-inch has lost half its muzzle penetration, whilst the 12-inch has lost but a quarter. Thus at 3000 yards the 12-inch will pierce treble what the 6-inch does, instead of double. And yet the 12-inch has not sufficient armor allowed it as compared with the 6-inch, even if the muzzle penetrations only be considered, so that under practical fighting conditions the big guns are now at a great disadvantage. These errors being common to all nations, the first Power that brings out improved designs will, by getting the start, reap a considerable advantage. It is to be hoped that this may be Great Brittain rather than some foreign rival. —*Brassey's Naval Annual* 1902.

Powders.

About the year 1890 guns of 40 to 45 calibres began to be manufactured, and there has been very little change since then in the length of the gun. All nations have adopted heavy guns of from 40 to 45 calibres, whilst 45 to 50 calibres are the accepted lengths of 6-in. guns and under. One of the first 40-calibre guns to be mounted afloat was the British 4.7-in. Q.F., which was closely followed by the 6-in. Q.F. These guns have a velocity somewhat below 2200 f.s., which ten years ago was considered a very high figure. As smokeless powders developed, the chambers of guns were enlarged and higher velocities were attained, and five years ago the velocity aimed at in new designs of guns was from 2500 f.s. to 2700 f.s.

But it was found that when such velocities were obtained with nitro-glycerine powders, of which cordite and ballistite may be looked upon as the best known examples, the erosion proved to be very troublesome. The high temperature, combined with the rush of gas, causes a rapid enlargement of the gun at the point where the rifled part of the bore begins. The action of the gas is most apparent in attacking the lands, which, after a time, are so completely worn away that the gun becomes a smooth-bore for some distance from where the rifling commences. A heavy gun, after not much more than 100 rounds with full charges,* may be enlarged as much as half an inch, and would lose 150 f.s. or more in muzzle velocity. If firing be continued, the destruction of the rifling will presently become so serious that the projectile will not be properly rotated. The gun has then to be relined.

A consideration of these facts has caused a widespread desire for some propellant that would give the high velocities universally demanded without excessive erosion. All nations, save Great Britain and Italy, have now adopted some form of nitro-cellulose with which higher velocities can be obtained than with cordite, whilst the erosion is much less. In Great Britain experiments are being made, and the land service have adopted a modified form of cordite (Cordite M.D.) which contains less nitro-glycerine than the old service type. But it is understood that the Navy are not satisfied that the modified cordite is worth adoption, and that they prefer to wait until the Explosives Committee are in a position to recommend the adoption of a pure nitro-cellulose propellant.

A paper by Lieutenant Turpin, U.S.N., gives some interesting figures with regard to results obtained with the nitro-cellulose propellant adopted by the United States Navy. Thus we have the following, showing what has been done with a 50-cal. 6-in. gun in America:—

UNITED STATES SMOKELESS POWDER.

Weight of of gun.	Charge.	Projectile.	M. V.	Energy.	Energy per lb. of powder.
tons.	lb.	lb.	f.s.	f. t.	f.t.
8.4	45.5	100	2922	5919	130

Lieutenant Dawson, R.N., of Vickers, Sons, and Maxim, to whom very much of the recent progress in gunnery in this country is due, gives the following figures as having been obtained in a 6-in. gun of 45-cal., the capacity of the chamber being 1560 cubic inches, as compared with 1715 cubic inches, the corresponding capacity for 6-in. Mark VII.:—

ROTTWEIL SMOKELESS POWDER.

Weight of gun.	Charge.	Projectile.	M. V.	Pressure.	Energy.	Energy per lb. of powder.
tons.	lb.	lb.	f. s.	tons.	f.t.	f.t
7	34	105	2844	17.9	5890	173
7	34	100	2922	17.2	5923	174

Here we have a charge of only 34 lb. Rottweil nitro-cellulose giving the same energy in a 45-cal. gun as that obtained in America with a 45½-lb. charge in a 50-cal. gun.

There is no doubt of the superiority of the latter propellant. The following figures also show what a high power can be obtained from Vicker's 7 5-in 50-cal. gun with a very moderate pressure:—

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* This does not prevent practice, for a reduced charge may be used which does not give one-tenth the wear of a full charge.

ROTTWEIL SMOKELESS POWDER.

Weight of gun.	Charge.	Projectile.	M.V.	Pressure.	Energy.	Energy per lb. of powder.
tons.	lb.	lb.	f.s.	tons per sq. in,	f.t.	f.t.
15	80	200	2903	15.9	11,700	146

It will be remembered that the German Rottweil firm was very much to the fore when brown powder superseded black. The same firm is once more to the fore now that it is a question of improving on cordite. It is hoped, however, that a British product may yet come to the front, and that we may not have to go abroad for our supplies of nitro-cellulose, as we did for brown powder.

The following charges of nitro-cellulose and cordite gave the same velocities in the 6-in. Mark VII. gun - viz., 2922 f.s.

	Weight.	Cartridge.			Size of chamber of gun.
		Diam.	Length.	Cubic contents	
	lb.	in.	in.	c.in.	c.in.
Cordite	29.6	6.3	22.5	701	1820
Rottweil Nitro cellulose	34	6.5	31.2	1033	1560

The nitro-cellulose charge is 30 per cent. bulkier, and more magazine space will therefore be required, but the gun-chamber need not be so large, which is a decided advantage. Moreover, the 29½-lb. charge of cordite is practically inadmissible, owing to the enormous erosion, for which reason the present service charge of the 6-in. (VII.) 45-cal. gun is only 20 lb., giving an energy of 4300 ft.-tons as compared with, say, 5700 ft.-tons, which seems likely to be about the service energy with nitro-cellulose.

In the tables forwarded by Herr Krupp, which appear at the end of this section, the ballistics are apparently given for Rottweil powder, and even if some allowance be made for a manufacturer's estimate, which is often somewhat sanguine, there is no doubt that a great advance has been made, and that for the future velocities will not be much below 2900 f.s.

In the table published on the authority of Lieutenant Turpin, U.S.N., the following excellent result with a 40-cal. 12-in. gun is also given:—

Wt. of gun.	Charge.	Projectile.	M.V.	Energy.
tons.	lb.	lb.	f.s.	f.t.
52	353	850	2822	46,950

Krupp's figures for a 40-cal. 12-in. gun are almost identical—viz., 45,500 ft.-tons of energy.

The American 50-cal. 5-in. gun has also passed a satisfactory proof, the velocity being 3200 f.s. with 60 lb. shell and pressure 18 tons, showing that the estimated velocity of 2900 f.s. can readily be reached without exceeding the service pressure of 16 to 17 tons.

We may take it, then, as fairly well established that velocities of from 2800 f.s. to 2900 f.s. will soon be common enough both for heavy and light guns, always supposing that nitro-cellulose exhibits good keeping qualities and gives regular results. Some of the rounds reported from the United States leave a good deal to be desired in respect of regularity; thus, in the Gathmann trials, the 12-in. Army gun gave the following results with two similar charges of Dupont smokeless nitro-cellulose:—

Charge.	Projectile.	M.V.	Pressure.	Muzzle energy.
lb.	lb.	f.s.	tons per sq. in.	f.t.
237	1001	1807	9.5	22,685
237	1045	2080	12.8	31,395

Here we have a difference in energy of 8710 ft.-tons in two rounds. The first charge, for some reason not explained, only gave the extremely meagre result of 96 ft.-tons per lb. of powder, whilst the second gave the fairly normal result of 132 ft.-tons. There was thus a difference of some 36 per cent. in the two rounds, showing that the first dharge did not ignite properly.

Again, we have in the 4-in. 50-cal. gun:—

Charge.	Projecctile.	M.V.	Pressure.
lb.	lb.	f.s.	tons.
15.5	32	2891	15.9
17.6	32	3046	17.6

The difference is not so startling, but still it is considerable, and there seems a good deal yet to be learnt in America as to the best method of obtaining regular results with certainty.

The American nitro-cellulose powders are difficult to ignite—more difficult than cordite—and therefore require large primers of black powder. The result is that there is an appreciable amount of smoke, especially with the larger calibres. The charge for the 13-in. American gun has primer of rifle powder weighing no less than 14 lb.; the 12-in. gun used for the Gathmann trials had 7 lb. only. Possibly the relatively small primer used on that occasion may account for the irregular velocities. The reduction of the primer beyond a certain point causes long hang-fires, decreased velocities, and increased pressures. Primers of smokeless powders have been tried without success, and at present, at any rate, there is no efficient substitute for black powder. When a smokeless primer was tried in the 6-in. in America there wes an appreciable hang-fire, and the pressures rose from 16 to 20 tons.

There have been various explosions owing to the accidental ignition of smokeless powders, but whether caused spontaneously or otherwise is not altogether clear. At Mare Island Navy yard, San Francisco, a magazine containing 300 tons of smokeless powder, worth £100,000, exloded on June 5th, 1901. In this instance there was no one near the magazine, so that there seems no other explanation save that the explosion was spontaneous. It is understood that since this accident a good deal of the smokeless powder issued to American ships has been condemned, but the naval authorities appear to be satisfied with the type of powder now being made, which is presumably a decided improvement on that condemned.

The cost of nitro-cellulose will apparently be more than double that of cordite; not only is it more expensive weight for weight, but far larger charges are used to obtain high velocities. Thus a single nitro-cellulose charge for the American 12-in. gun costs £60, and eighty rounds £4800. The corresponding figures for 12-in. Mark IX. using cordite would be about £1600 for eighty rounds. Any economy gained by the decrease of wear, which renders lining less frequent, is more than compensated for by the extra cost of the ammunition.

But since higher velocity can be attained with nitro-cellulose it seems bound to come in, regardless of cost—provided that regular results can be obtained and the stability of the product is assured, and with reference to this there is every reason to be confident that such difficulties as exist will be overcome.

The advantage of increased velocities is twofold. First, the "dangerous space" being increased, the humber of hits in a given time is greater, and, secondly, there is greater damage on hitting both with shot or shell. To take the latter first, it is not commonly known that the damage done by a shell is much more due to the velocity at which it was travelling before it burst than to the action of the bursting charge. The main value of the latter is to scatter the fragments. If a shell be burst at rest, none of the more important fragments attain a velocity of more than 500 f.s., and the majority much less than this. But if the shell be burst when it has a velocity of 2000 f.s., the velocity of the fragments is from 1500 f.s. to 2500 f.s., and there energy is sixteen-fold greater than if the burst took place at rest. The above refers mainly to common shell. The additional value of armour-piercing shot and shell owing to an increase of velocity is readily to be gauged by the increase of piercing power and the greater destruction after penetration.

The following table shows some of the improvements that have taken place, especially as affecting ships still occupying an honorable place in the list of effective men-of-war:—

GUNS FORMING THE PRINCIPAL ARMAMENT OF BATTLESHIPS AND ARMOURED CRUISERS.

Penetrating Power and Rate of Fire of Heavy Guns.

Ship.	Guns in order of piercing power.	Weight.	M. V.	Weight of projectile.	Penetration Krupp steel 3000 yds.	Rate of fire.
		tons.	f.s.	lb.	in.	Rds. per min
Georgia . . .	12″ 40 cal.	52	2800	850	16.0	—
Tsarevitch . .	12″ " "	—	2750	731	13.5	—
Implacable . .	12″ " "	50	2500	850	13.0	1.2
Suffren . . .	12″ " "	—	2870	644	13.0	—
Majestic . . .	12″ 35 cal.	46	2370	850	11.5	0.9
West Virginian .	10″ 40 cal.	34	2800	500	11.5	1.5*
Royal Sovereign	13.5″ 30 cal.	67	2020	1250	11.0	0.4
Cressy	9.2″ 46 cal.	27	2650	380	9.5	3.0
Renown . . .	10″ 32 cal.	29	2040	500	7.0	0.7
Devonshire . .	7.5″ 45 cal.	14	2800	200	7.0	3.5*
Edgar	9.2″ 32 cal.	24	2060	380	6.0	0.7

* Estimated.

If we consider the heavier guns, we see the very great advantage that the Geargia holds over the Majestic owing to the improvement in 12-in. guns. The penetration has increased 40 per cent., and the rate of fire may probably be greater.

* * * * *

The following table shows how the matter stands as regards improvements in the Q.F. guns:—

Ship.	Guns in order of piercing power.	Weight	M. V.	Weight of projectile.	Penetration Krupp steel 3000 yards.	Rate of fire.
		tons.	f.s.	lb.	inches.	
New U.S. battleship . . .	7″ 50 cal.	13.3	2900	165	6.5	3.5*
République	6.48″ 45 cal.	—	2870	115	5.5	4*
King Edward	6″ 45 cal.	7	2800†	100	5.0	4
Implacable	6″ 45 cal.	7	2500‡	100	4.0	4
Charlemagne	6.48″ 45 cal.	6½	2025	99	3.8	4*
Majestic and Royal Sovereign	6″ 40 cal.	7	2150‡	100	3.2	4
Kaiser class	5 9″ 40 cal.	6	2400	88	3.2	4
Bouvet	5.46″ 45 cal.	4	2525	66	3.2	4*

* Estimated. † With nitro-cellulose. ‡ With cordite.

As with the heavy guns, the improvements of the last few years have increased the penetration of a gun of given calibre more than 50 per cent. But in the same period the protection of the secondary armament has gone up 100 per cent., so that it is necessary to increase the calibre of the gun. The French have gone up from 5.46 to 6.48, the Americans from 6-in to 7-in., the Germans are likely to adopt a 6 7-in gun, and we should certainly adopt the 7.5-in. as a battleship gun. It will deal with 7 in. of Krupp armour at 3000 yards, which is an immense improvement on the 5 in. of the best 6-in. gun.

—*Brassey's Naval Annual* 1902.

WARSHIPS AND TORPEDO BOATS.

Belleisle Experiments: Second Series.

"The Belleisle, hulk, which has been specially fitted up for experiments, was on Tuesday fired into, off Bembridge, Isle of Wight, by the gunboats Pincher, mounting a 9.2-inch gun, and the Comet, armed with a 6-inch gun. A 20-ft. section of the Belleisle on each bow had been fitted with a type of of plate manufactured by Messrs. Cammell and Co., of Sheffield, the principal feature of the plate being that it was only partially Krupped, in order to ascertain the elasticity and resistance of a plate made under these conditions. In thickness, the 6-in. plate on the starboard side of the Belleisle represented the armor of the Drake class of cruiser, and the 4-in. plate on the port side the armor of the "county" class. Internally the ship in the armored section was fitted with bunkers, transverse bulkheads, and other supports such as would be found in the armored area of seagoing ships. The new form of lyddite, as well as armor-piercing projectile, and common shell, were used, and the utmost precautions were taken to police the vicinity, both ashore and afloat, in order to prevent unauthorized persons from coming within a clear view of the operations. In all ten rounds were fired, the 6-in. plate being first attacked. Two rounds were fired from the 6-in. gun, followed by two rounds from the more powerful weapon, and after each pair of rounds the ship was visited by the Lords of the Admiralty, and photographs were taken. The Belleisle was moored broadside on to the shore, and after the thicker plate had been tried the ship was turned round, and the port side was fired into, when again both guns were used. As far as could be seen from the shore the the concussion at each round was so great as to cause considerable débris, and ultimately it looked as though the 9.2-in. gun had penetrated the 4-in. plate, as the vessel appeared to be sinking. She was drawing 15 ft., and had only 16 ft. of water under her; so that when a party of bluejackets had gone on board and patched up the leaks, it was found possible, with the extra provision of collision mats, to tow her back to Portsmouth."—*Engineerihg*, London, February 21, 1902.

"Belleisle" Tests.

The first lord of Admiralty and rear-admiral May visited Portsmouth to examine the results of firing against the old Battleship "Belleisle" on which tests were recently made to determine the power of resistance of the new armored cruisers. The Belleisle was inspected with minute care. It was found that the armor was pierced many times by projectiles and many lodgments made in the interior of the vessel, which proved that the type of armored cruisers now under construction is vulnerable by guns less powerful than those which form the principal armament of battleships.

—*La Marine Francaise*, April 15, 1902.

GUNNERY.

Target Practice North Atlantic Squadron.

Unusual interest has attached to the tests just completed outside the Virginia Capes by Admiral Higginson's Squadron. Advantage was taken of the opportunity to test, not only the accuracy, but also, the rapidity of fire of the different calibres; rapidity of fire, in the light of recent experience, being recognized as an imperative necessity.

In foreign navies, the improvement in matériel and training of personnel to meet this necessity, has been very swift. It is gratifying to know that our Navy has lost no distance in this race and that the superiority of American gun-fire is not seriously threatened. Especially satisfactory was the work of the 13″ guns of the Kearsarge, (Capt McCalla), one of which, after having been fired, was reloaded and fired again in one minute, hitting the target. The same gun was fired three times in succession in four minutes hitting the target each time. Out of a total of ten 13″ shots, seven were hits.

The object of the firing was—

First.—To compare our results with those of other navies, as the conditions of practise as to size of target, speed of ships, and intervals of fire were similar to those used in Annual Prize Firing of other navies; although the range was purposely made greater, the others using 1600 yards, and our range being 1760 (one statute mile.)

Second.—To determine the firing interval of our various types of guns as mounted on these ships.

Third.—To note the effect of the winter's training in the improvement in target practice.

Fourth.—To study certain defects in ordnance which it is claimed are partly accountable for the slowness of fire, and inaccuracy or failure to hit.

The target for this practice, 20 feet long by 16 feet high, was placed at the vertex of an isosceles triangle whose equal sides were one mile in length; the ship steamed outside and parallel to the base of this triangle at a speed of eight knots in the case of 8″ and 13″ guns and 12 knots in the case of 5″ and 6″ guns. During a part of the practice there was a nasty sea. In order to avoid fouling the anchor lines of the buoys marking the ends of the base of the triangle it was necessary to keep about 100 yards outside of the buoys, (one ship got too close and fouled one of these anchor lines); the range therefore varied from a little over a mile to a little under a mile; the officer in immediate charge estimated the range which was laid off on a scale graduated to yards only; this officer also furnished the deflections.

Service projectiles and charges were used.

On the Kearsarge electric power is provided for traversing the guns horizontally; they are elevated by hand and electric power, separate elevating gear being provided for each gun. The projectiles and powder charges are conveyed directly from the ammunition chambers to the gun by means of hoists. The ammunition cages are raised by electro-motors and take up one projectile and charge at a time. The guns are loaded at a fixed horizontal loading position, the electric rammer, operated by electro-motor, being in prolongation of bore in fixed loading position. This fixed loading position (horizontal) is believed to be superior to any in which the fixed position is inclined, but the system which permits of loading at all elevations and azimuths possesses the advantage that the gun can be kept laid in elevation and azimuth and fired as soon as loaded.

In the important matter of the preference for electrical power for working mountings instead of hydraulic power as used in some navies the advanced position of the American Navy in the matter of electrical appliances is believed to be justified. The advocates of hydraulic power claim that in case of injury the damage is easily located and repaired; hydraulic machines can, in most cases, be applied direct for elevating, lifting ammunition, and for handling projectiles, etc., in the shell rooms and other parts of the ship; the movements of the gun are under better control, the dead-slow movement required being readily obtained.

Objection is made to electro-motors because, if of reasonable size, they must be run at high speed, with much gearing, with consequent loss of power and attendant noise. Difficulty is experienced in locating the cause of failure in the motors, conductors or controllers. It is also well-nigh impracticable to use electricity for running heavy guns back to the firing position.

In the American service this latter objection has no weight, for the reason that spring return is used, the complication of hydraulic power being altogether avoided and pipes made unnecessary. The electrical conductors have a great advantage in the matter of weight, require little space and are readily adaptable to surroundings. Again, any break is more readily repairable though a break in hydraulic pipes is doubtless more easy to locate.

Rapidity and Accuracy of Fire.

It is not so many years ago that the excellent custom was introduced of having trials of guns and mountings on board a new ship, but these gunnery trials of ships went on for some years before a rapidity test was instituted. It is now so thoroughly recognized that rapidity in loading, laying, and supply of ammunition is one of the most important features in guns of all sizes and styles that rapidity trials are carried out almost as a matter of course on the completion of a ship.

Sir W. Armstrong and Co. have always been to the fore when any improvements in the mounting and working of guns have been in question, so that it is natural, in reviewing the advance that has been made during the last twelve months, to refer first to the trials of ships in which Elswick mountings are used.

The Mikasa, if not, as many hold, the finest battleship yet completed in this country, is undoubtedly equal to the best, and her trials were naturally looked forward to with great interest. The ship is generally similar to our Formidable, but she carries very little armor before and abaft the barbettes. On the other hand, she has a main deck battery in lieu of casemates, with each gun completely isolated from its neighbour by 2-in. screen bulkheads. She also has 14 6-in. Q.F. in lieu of 12 in the British ship. Last, but not least, her barbettes have 14-in. armor in lieu of 12-in.

Trial of Rapidity of Loading 12-inch Gun.

	Round.	Time from "Load" to "Ready" or "Fire" sec.
After barbette (without laying).	1	40
	2	40
	3	50
	4	30
Fore barbette (laid at target).	Starting with gun empty. Loaded and fired 3 rounds in 2 min. 23 sec., or 48 sec. per round.	

Note.—A mistake with a lever caused a delay of 25 sec. But for this the time would have been 40 sec. per round.

The breech was worked with the greatest ease throughout. The screw is practically parallel. The mounting consists of the usual turret and turntable, with heavy oval shield running on a roller ring. A working chamber is attached beneath, in which the work of transferring the ammunition from the central tube to the loading hoist is carried out. The ammunition hoist in the Mikasa differs from that in the Formidable in that the charge and projectile come up together in the Japanese ship and separately in the British one. The ammunition hoist having brought up the charge and projectile to the working chamber, it is there shifted to the loading hoist, which conveys the loading cage up to the gun-chamber, where the guns are locked at an elevation of 4½°, so as to be opposite the chain rammer and loading cage.

In the Formidable the trials consisted of firing the guns alternately in the the service manner. This is slower than firing independently, for a gun may have to wait for its neighbor. Starting with both guns empty, the two guns fired ten rounds between them in 4 min. 56 sec., or one round per minute from each gun.

Curiously enough, if there is no error in the newspaper reports, the rapidity trials of the Irresistible gave almost identical results—*viz.*, 4 min. 46 sec. for ten rounds. Presumably the guns were empty at the start, though it is not so stated.

The Irresistible's mountings are to designs submitted by Vickers and Co. In this type the loading gear and cage are attached to the slide of the gun, so that the loading can be carried out at any elevation. The weight of the loading gear also acts as a counter-balance to the chase of the gun, and allows of the guns being placed further out, so that the muzzles project further over the ship's side than would otherwise be the case, a most important matter when considering the effect of blast on neighboring guns. The above times cannot be considered as representing what may reasonably be expected from a thoroughly trained crew. The men, though smart and capable, were strangers to the mechanism, and we confidently expect that ten rounds will yet be got off in 4 min.

The conditions for prize-firing are similar to those prevailing in the Mikasa trials—one gun only being fired as quickly as possible. Under these conditions the Mars, starting with the gun loaded, fired eight rounds in 6 min., or, allowing 10 sec. for firing the first round, at the rate of 50 sec. per round. But the Majestic class are allowed in prize-firing to use the all-round auxiliary loading position, to which the supply of projectiles is most faulty, for only eight shell are carried there, and they cannot be replaced without great delay, After the eight rounds the rate of fire of the Mars would be reduced about 50 per cent., so that the above is not so much a practical demonstration of what the Majestic class can do, but rather an argument for rearranging the loading arrangements of these fine ships. The fixed loading station is most objectionable, not only because the rate of fire is much slower, but also because of the serious exposure of the guns and barbette-hood when loading; besides which the guns have to be loaded simultaneously, but fired in succession, so that after a gun has fired it cannot begin loading until its neighbour has been discharged. Thus, besides the time lost in training to the fixed loading position, which, being fore and aft, means training 90° in the ordinary broadside action, there is the further loss of time due to the guns waiting for each other.

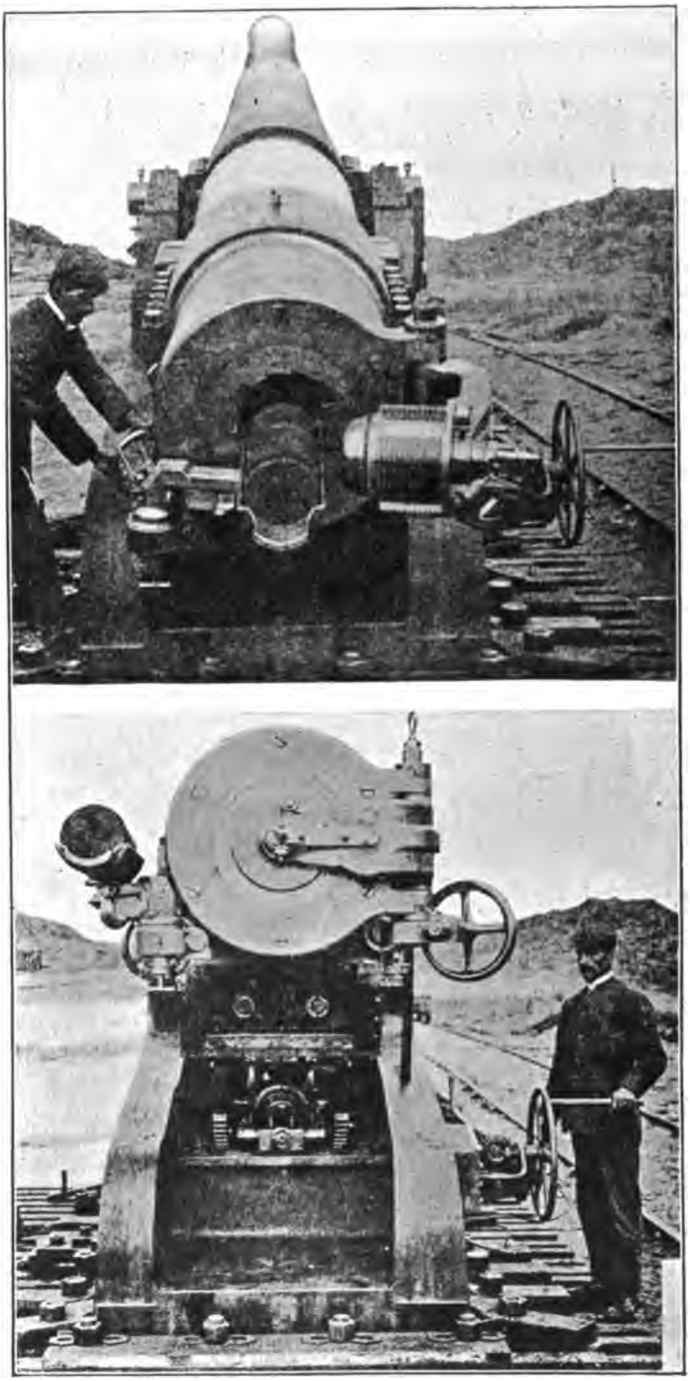
The Glory, with all-round loading gear, fired 28 rounds from four guns, each gun firing for 6 min. (starting loaded). It is very possible, therefore, that one or more of her guns may have equalled the eight rounds fired by the Mars.

The working of a pair of guns in the same barbette undoubtedly leads to difficulties, and as regards rate of fire the single gun will always have an advantage over one of a pair. Some of the success in obtaining rapidity of fire from the 9.2 in. is due to this cause, but much must be attributed to the improvements in handling the projectile which have been introduced by Messrs Vickers, and to a lesser degree the simple method of working the breech. The former is shown in Plate. The projectile is hoisted by power to a swinging loading-tray attached to the cradle. The breech opens to the right, and the projectile is immediately swung in from the left. The breech is worked by the single motion of a long lever, as shown in Plates. This has a considerable advantage as regards rapidity over the hand-wheel gear, always supposing the pad is readily seated and does not stick when opening the breech. Trouble has occurred with sticking pads in opening the breech, and more still in closing; but various remedies are being applied, some one of which may, it is hoped, prove successful.

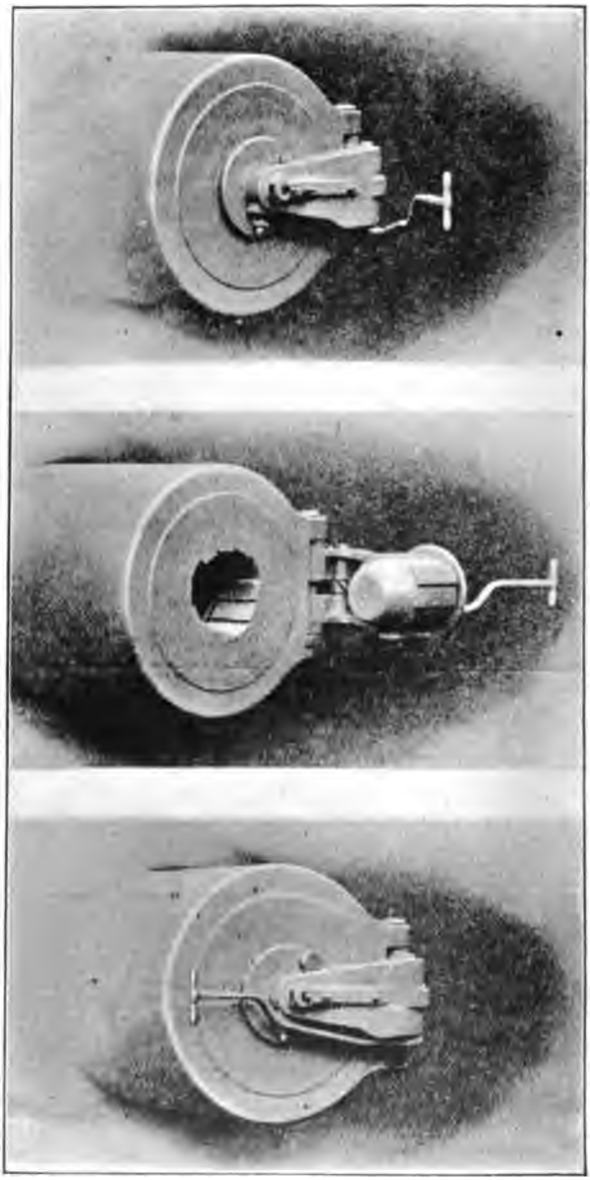
The following rates of fire have been obtained with the 9.2-in., the gun being fired under service conditions:—

H.M.S. Cressy	5 rounds, 100 sec.
Experimental gunboat	" 90 "
H.M.S. Aboukir	" 85 "
H.M.S. Sutlej	3 rounds per minute easily.

The 9.2-in. gun is therefore a genuine Q. F. as at present mounted. The improvement is immense. The guns of the Edgar class, the last of which ships was not completed till 1804, take 86 sec. between two rounds. The rate of fire has then, therefore, increased from four to five times, and the two guns of the Aboukir class are worth eight in the Edgar class. This promotion of



9.2-in. B. L., with Vickers Loading Tray.



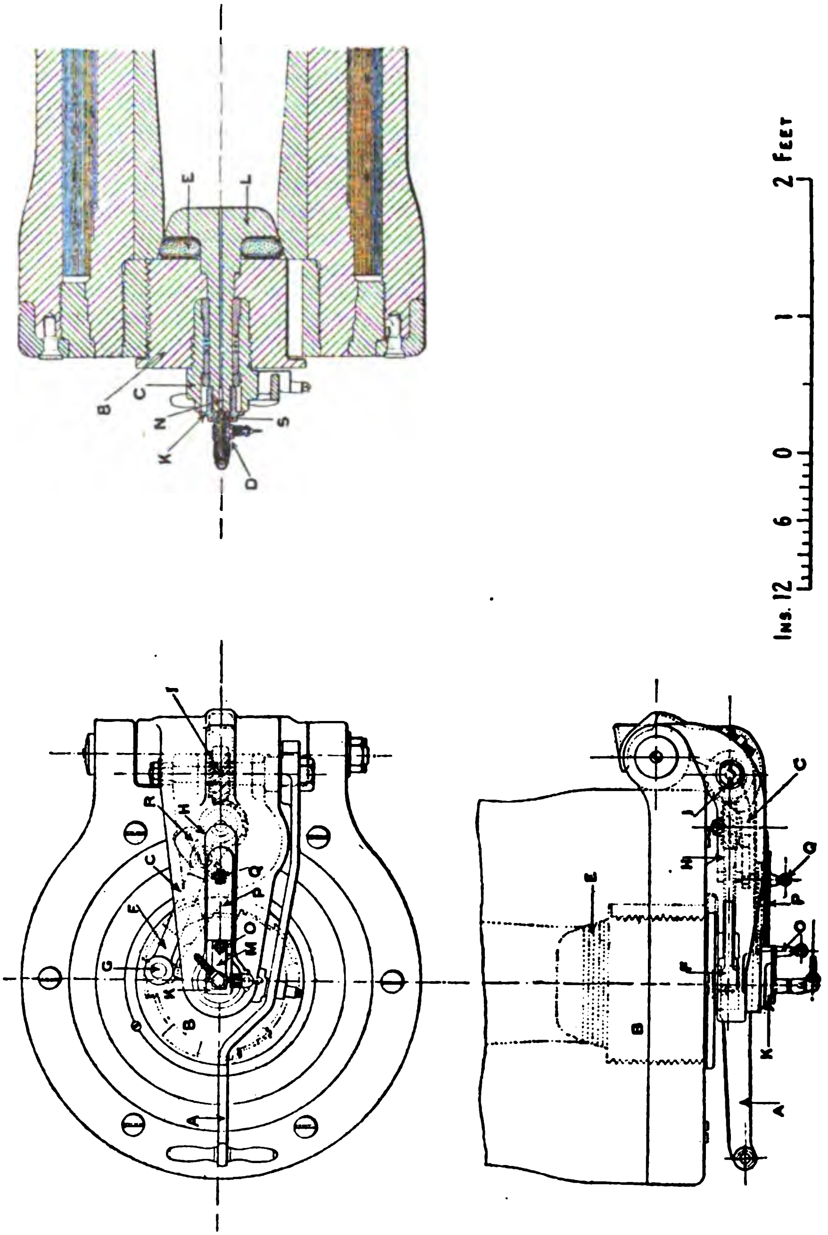


Plate XV.—Vickers Breech Action. 9·2-in. B.L.

the 9.2-in. to the ranks of the Q.F. makes it inevitable that this gun will shortly be the principal weapon in the secondary armament of our new battleships.

Unfortunately, as stated above, a long period must elapse—two years at the very least—before we shall be able to report on the gunnery trials of the first service 7.5-in. gun. Experimental guns of this calibre have given promising results,but this is not the same thing as having the guns mounted for service in their own turrets with all ammunition supply arrangements complete. Still, it is not amiss to mention the very high rate of fire attained at Messrs. Vicker's experimental range at Eskmeals with a 50-cal. gun of this calibre. Starting with the gun loaded, five rounds were fired at a fixed target 24ft. x 16 ft. Range 1100 yds.; all hits; time, 37 sec. If we assume that the first round was fired in three seconds from the order "Commence", this is at the rate of seven rounds per minute. The rate of fire afloat should closely approach that of the 6-in. Q.F., always supposing the turret training and elevating gear to come out satisfactorily.

For many years after the institution of prize-firing, it was generally thought that the competition was to be between similar guns in the same ship and not between different ships. The reason is clear that it was considered impossible to institute a fair comparison between ships which fired on different ranges on different days, with all kinds of varying conditions of wind and weather, to say nothing of different types of guns and mountings. On some stations smooth water and calm weather can be counted on; on other stations rough weather and a nasty swell are the rule. There are sometimes so many ships waiting to fire that practice must needs go on, be the conditions favorable or not. At other times it is possible to wait for a fine day.

Nevertheless, there is no doubt that the competition between similar guns in the same ship did not arouse much interest or enthusiasm. Jack has never shown a mercenary disposition; and had he done so, the prizes were not of sufficient amount to tempt his cupidity. So for some years the regulation prize-firing was regarded as a formal function which had to be gone through with, and which might possibly interest some few enthusiasts who were mad on guns. For the ordinary Executive officer—the officer of the quarters—or petty officer—captain of the gun—it was one of those aggravating occurrences like the dismounting of guns for examination, or the survey of cables, that in a well-ordered ship come now and again to upset the steady business of getting the ship and ship's company into "thorough good order." All this has completely altered during the last few years. "Gunnery, gunnery, gunnery," says Lord Selborne, is of supreme importance: and in looking about for a test of good gunnery the annual prize-firing at once presents itself as at any rate some indication of efficiency. So it has come about that ships have begun to compete against ships, and on one station, at any rate, under the patronage of the admiral. The commander-in-chief in China has given a challenge shield for the ship which does best, the comparative merit being assessed by an elaborate system of points; and last, but not least, the papers publish results which, although it may not affect the zeal of the captain, commander, or gunnery officer, does certainly incite the crews to greater exertions, and so far is doing good to the service.

It is urged by some that prize-firing is a very uncertain test of efficiency; that the conditions are far removed from those that will prevail in action. The range is known, only one gun fires at a time, it is all rehearsed beforehand over and over again, and so on. This cannot be denied. But the same may be said of almost any test that human skill can devise There can be no doubt that the keenness which has arisen over the prize-firing competition, especially in China, is an excellent sign of vitality, and that the ship that excels in prize-firing will also excel in other gunnery tests. Already there are schemes afloat for testing the hitting power of the whole ship rather than that of the individual gun, and we look forward with confidence to a steady advance in this direction. It is a notable fact that the 40 per cent. of hits, which is the average for the China Station, compares most favourably with the average of some years past, which stands at about 30 per cent.

In commenting on last year's prize-firing, we labour under the disadvantage that only a portion of the results have been published. Still, it seems probathat we have the best results before us, for otherwise the statements that this ship or the other had established a record would certainly have been contradicted. At any rate, we have a very full report of the result of all the firing on the China Station which appeared in the *Times.*

Taking first the results, obtained with heavy guns mounted in barbettes, it must be remembered that the target has an oblong centre, 20 ft. long and 15 ft. in height, with two jibs at each end, which extend the water-line to 50 ft. Thus the lower part of the target might represent part of the water line of a ship, whilst the centre stands for a barbette or turret. But a barbette would measure 32 ft. in breadth and 25 ft. in heigt, so that its dimensions are 60 per cent. greater than that of the target, and it should be as easy to hit the barbette at 2500 yards as it is to hit the target at 1700. But seeing that hits towards the edges of the barbette would glance off, it would be about as easy to pierce the armour as to hit the prize-firing target. The rapidity with which the bearing and distance alters, whilst the ship steams past the stationary target at 8 knots, is probobly very fairly representative of the conditions of firing in a broadside action, which, in our opinion, will be the ordinary fight of the future.

In every case the practice starts with the gun loaded. When the rate of fire is slow, this makes a very material difference. For example, a gun taking nearly 2 min. to load fires the first round in 10 sec. from "Commence," and may get in four rounds in 6 min.—thus: (1) 10 sec.; (2) 2 min. 6 sec.; (3) 4 min. 3 sec.; (4) 6 min.—and be credited with one round in 1 min. 30 sec. in lieu of 1 min. 56 sec., the true time. Of course "Cease Fring" might sound as the gun came to the "Ready," when 1¾ min. would be wasted. A fair way of assessing the rate of fire is to take away one round from the total of each gun and deduct from the time for the gun half the average time between two rounds, to allow for waste at the end. Thus the Ocean fired 26 rounds in four runs of 6 min. each.

Deduct 4 rounds from 26 = 22 } Result, 1 round per gun per min.
Deduct 2 minutes from 24 = 22 } Hits per round, $\frac{14}{26}$ = 0.54.
No. of hits = 14 } Hits per gun per min = 0.54.

BEST RESULTS WITH HEAVY GUNS.

(Target, 15 ft. high; area, 525 sq. ft.; range, 1400–2000; speed, 8 knots.)

Ship.	Station.	Gun.	Rounds per gun per min.	Hits per gun per min.	Hits per cent.	Weight of metal hitting per min.	Remarks.
						lb.	Guns in double barbettes
Ocean	China	12″ VIII.	1.0	0.54	54	460	All round loading gear, shell from below.
Mars	Channel	do.	1.0	0.42	42	357	Auxiliary loading gear (all round) shell from barbette
Barfleur	China	10″	0.93	0.46	49	230	..
Terrible	China	9.2″ VIII.	1.75	1.12	64	426	Guns in single barbettes.

BEST RESULTS WITH Q.F. GUNS.

(Target, 15 ft. high; area, 300 sq. ft.; range, 1400-1600; speed, 12 knots.)

Ship.	Station.	Guns.	Rounds per gun per min.	Hits per gun per min.	Hits per cent.	Weight of metal hitting per min	Remarks.
						lb.	
Terrible	China	6″ Q.F.	5.33	4.25	81	425	
Ocean	China	do.	4.80	2.67	56	267	
Mars	Channel	do.	4.67	2.58	55	258	
Barfleur	China	4.7 Q.F.	7.95	5.70	72	256	

Note.– Average rate of fire and hitting for last three years:

	Rate of fire.	Rate of hitting.
12″ VIII.	0.88	0.27
10″	0.70	0.22
9″ VIII.	1.30	..
6″ Q.F.	3.8	1.1
4.7″ Q.F.	5.3	1.7

In every case these ships attain their excellence (1) by a rapidity of fire much above the average, (2) by a percentage of hits very much above the average.

There can be no doubt of the pre-eminence of the Terrible (Captain Percy Scott). Her 9.2-in. guns, being on mountings special to her particular type of ship, cannot be compared as regards rate of fire with any other gun, but one round per minute was considered good when these guns were first tried; this has been increased by 75 per cent. The percentage of hits is the highest for heavy guns. With 6-in. Q F. guns, the Terrible's record of 4.25 hits per minute is as nearly as possible four times the average and stands far above every other ship.

The Barfleur stands a very good second. The rate of fire of both 10-in. and 4.7-in. guns is far above the average, and the rate of hitting of the former more than twice the average, whilst that of the 4.7-in. gun is three times the usual figure.

The Ocean and Mars have done very well. If we look at the hits per minute of the heavy guns, we see that any of them would make exceedingly short work of a rival's barbette, provided they could pierce it. A pair of guns in the Mars and Ocean would pierce a rival's barbette about once a minute at a range of about 2000 yards. The Barfleur would hit as often, but, owing to lack of power, could not pierce. The Terrible's 9.2 in. would deal destruction anywhere in a large armoured cruiser, whilst her 6-in. guns would make short work of the smaller type.

The column showing the weight of metal is remarkable. The little 4.7-in. beats the ponderous 10-in. of ten times its weight. The 6-in., which weighs one-eigth of the 12-in. throws two-thirds as much metal into an enemy. Obviously, if a battle is to be decided by weight of hits, apart from piercing power, the smaller guns are far the best Therefore, as the heavy guns cannot compete as shell guns, they should go in specially for piercing, and the main supply of projectiles should be armour-piercers.

It is with the Q F. guns that the highest excellence is attained. In these guns the rate of loading depends in very great measure on the training of the crew, especially in the rapid and skilful handling of the charge and projectile. Captain Scott, in order to train his men in these important matters, has made use of a dummy gun or loading apparatus which enables men to practise the loading in a way not possible with the gun itself. A similar apparatus has now been introduced into other ships. The electric aiming apparatus used in the Terrible also gives excellent practice in laying quickly.

The best gun in the Terrible fired eleven rounds in two minutes, as against 7.6, the average for the service, and made eleven hits, about five times the usual number. Two other guns also hit every time, so that with these wonderfully expert layers it was only a question of rapid loading who should win the prize. The layer is changed after firing for one minute. Five of those who made "highest possibles" took on firing in the middle of the run—always a trying ordeal. No less than ten men in the Terrible hit every time, and six others only missed once. None of the Barfleur's guns hit every time, and there was only one that did not miss twice; but three or four individuals seem to have made highest possibles. The quickest firing was 70 per cent. quicker than the average for the fleet.

Shooting with a Q.F. gun in measure resembles shooting at the running deer or similar targets. The Bisley prize-list shows that the same men win these prizes year after year. The great point is to discover these men and train them up to the required proficiency. It is by no means necessary—and, indeed, in many respects undesirable that the same man should command and lay the gun; therefore the choice need not be limited to petty officers.

With heavy guns the mechanism does so much of the work that it is impossible to improve the rate of fire to the same extent as with a Q.F. gun. Nor is it possible to continually keep the gun on the move so as to keep the sights on. Still, there is undoubtedly very much to be done in improving the practice with heavy guns, and now that so much interest has been evolved we shall probably see a great improvement.

The question of sighting bears very closely on the improvement of gun practice. A telescope sight was approved some two years ago, and we shall soon be able to judge by an examination of fleet averages whether the practice has been materially improved thereby. A good man will undoubtedly profit by the use of a telescope; an indifferent or stupid man will do better without. There are also atmospheric conditions that do not favour the use of a telescope, and it is absolutely necessary to have the ordinary sights as an alternative. Still, the introduction of a telescope is a step in the right direction and gives additional opportunities for the exercise of careful training.

There is one somewhat important matter that seems to have dropped out of view in the fitting of barbette and turret guns. These guns are protected by a heavy hood or turret, which is to safeguard the gun, mounting, and crew from the enemy's fire. But an extremely vulnerable and most important part of the mechanism is quite open to be shot away by the smallest Q.F. gun or the tiniest splinter of a high-explosive shell. We allude to the sights. Not only are the sights outside the barbette hood without any protection, but any fragments of shell glancing along the hood, or even the rush of gas from a melinite shell, will be almost certain to sweep them away. In the same connection our sighting hoods are extremely crude concerns as compared with those fitted to foreign turrets. The high projecting rim or combing should either be made of thick armour or there should be none al all. But, above all, there should be an alternative method of sighting the guns, which should be available after the sights outside the barbette hood have been shot away. The French and Germans make slits in the thick armour, so that the gun can be directed from the inside of the barbette. This may be desirable, too, when it is a question of avoiding the blast of one's own guns firing past the hood. Sights on the guns themselves could be used at moderate ranges, say up to 5000 yards or so, where the angle of elevaiion would not exceed 3°. Such sights would immensely add to the reliability of the present arrangements, which are not in the least suited for standing a heavy fire. We understand that the Elswick firm have the subject under consideration. In these days of prismatic telescopes, there should be no difficulty in having nothing above the roof of the barbette save the end of the telescope, which would pass through a small hole in the roof, all the sighting gear being inside.

—*Brassey's Naval Annual* 1902.

COAST ARTILLERY.

French Coast Artillery.

* * * * *

A coast battery consists essentially of a terre-plein provided with emplacements or platforms for the pieces. Towards the enemy, this terre-plein is ended by a wall or parapet which a superior slope of very gentle descent joins to the natural surface of the ground. The pieces fire en barbette or through embrasures. They are often separated one from another by traverses, especially when the battery might be exposed to oblique fire; the traverses then shelter magazines for stores, small depots of ammunition, filling rooms, and places for the men.

But, in general, and always when the battery is not traversed, it is completed by a certain number of subterranean arrangements: powder magazines excavated in rock; sunken shelters under the terre-plein, all proof against the most powerful projectiles.

* * * * *

—*Armée et Marine*

BOOK REVIEWS.

Die Franzvesische Feldartillerie: Organisation, Bewaffnung, Ausbildnung, Schiessen, Gefecht. H. Rohne, Generalleutnant Z. D. Berlin: E. S. Mittler und Sohn. 1902. Pp. 125. Price M. 2.50.

The appearance of the new French Field Artillery Drill Regulations of Nov. 16, 1901, attracted considerable interest in the military world. The French were the first to adopt the new type of long-recoil rapid-fire field piece, and this action in a sense marked a new epoch in the history of field artillery.

General Rohne, perhaps the greatest living authority on the tactics and and practical field use of field artillery, has undertaken the study of the French Field Artillery: its organization, armament, training, firing and battle tactics, and the work before us is the outcome of this study.

Its importance arises from the fact that so great a change in material necessarily affects the *tactics* of the arm, but, more than this, it must also affect the tactics of infantry in attack. Hence, the study of this pamphlet is essential to all infantry as well as to all field artillery officers.

In discussing the organization of the French artillery the author calls attention to great peace strength of the batteries, even greater in number of officers than the war strength, and this, on account of the fact that in time of war officers are liable to be detached, or, if extra officers are present they will be most useful in training the remounts, in instructing in riding, and in commanding reserve or newly organized batteries. The peace strength in men is 61 per cent. of that required in war and that of horses 42 per cent. The guns per battery have been reduced to *four*, but the caissons have been increased to 3 *per piece*, or double the old number. The *corps artillery* is preserved, which is contrary to the best usage, for the division commanders are thus deprived in peace time from getting familiar with the characteristics of an arm which they will use in time of war.

The armament is considered effective: it has a high rate of fire (17 shots a minute) and excellent ballistic qualities. Its principal weakness is its lack of mobility. The piece limbered up is not too heavy, but the piece unlimbered, as well as the body of the caisson unlimbered, are too heavy,—2420 pounds,—and the height of the wheels is too small. Another trouble lies in the hydropneumatic brake, that is, the *air pressure* requires air-tight cylinders.

The cannoneers not on horseback are armed with carbine and bayonet; the mounted cannoneers with revolver and sabre.

The drill and firing regulations for the new armament are discussed in the author's masterly way, for when still an artillery officer that was his great specialty. Of course, the main portion of the criticism is devoted to ranging, and on the whole General Rohne favors the present French method of trying to obtain *a sufficient effect as quickly as possible*, and not laying too great stress on extreme accuracy in ranging; he defends the *tir progressif*, which has been stated to be identical with waste of ammunition, and states his views in an argument of some length. The reduction in the rate of the trot from 220 to 200 meters per minute is evidently not approved of, and the rate of march of horse batteries, 9 km. an hour for marches of 35 km. is not regarded as high enough. In general, however, the orders of march and similar provisions of the regulations are praised by the author.

The battle tactics are also reviewed with great care and the differences between the new and the old, and between the French and the German are pointed out. One of the most important points of difference is the new regulation relating to artillery masses: the old French regulations and the present German regulations required early superiority of numbers of pieces and early mass *action*, while the new require early mass *development* but no more pieces are to be used than are absolutely necessary for the object in view, and lay great stress on rapid, sudden entry into action. The advantages and disadvantages of this change are discussed at some length.

In conclusion, the present, like all the author's studies, is a valuable addition to the literature of the subject, and any study of the French artillery will be incomplete without the careful perusal of this work. The text is illustrated by a number of diagrams, tables, etc. J. P. W.

Men and Memories. Personal Reminiscences, by John Russel Young. Edited by his wife May D. Young. New York and London: F. Tennyson Neely. Pp. 484.

Personal reminiscenses are always among the most attractive of literary productions, but when they are the memoirs of a man of such large experience and wide acquaintance as John Russel Young they acquire an added charm. Few men have the advantage of such intimate acquaintance with so many eminent men. His career was so varied, his sympathies and interests so deep and wide, and his heart was so warm and gentle, that he met many great men in his life in the first place, and they took a deep interest in him in the second for he quickly won their full confidence and affection. He was on the editorial staff of the Philadelphia *Press* before the Civil war, war correspondent at the first battle of Bull Run, private secretary to Colonel Forney in Washington, on Bank's staff in the Red River campaign, connected with Jay Cooke in placing the national loan, associated with Greely on the *Tribune*, sent abroad in connection with the national finances by the Secretary of the Treasury, was in Paris when the Commune fell, then on the editorial staff of the *Herald*, accompanied General Grant in his trip around the world, was appointed minister to China, again became associated with the *Herald*, was President of the Union League Club in Philadelphia, and, lastly, was appointed Librarian of Congress.

The people of whom he speaks in these Reminiscences were but a small part of those he called his personal friends, but even they form quite a galaxy: Bayard Taylor, Grant, Edwin Forrest, Abraham Lincoln, Walt Whitman, Charles Dickens, George W. Curtis, Wendell Phillips, James Gordon Bennett, Roscoe Conkling, the Duke of Marlborough, Edmond Yates, James Russell Lowell, Li Hung Chang, General Sherman, Lawrence Barrett, Hamilton Fish, Booth, Childs, John Sherman and Colonel Hay, these are some of the men to whom he devotes special articles, but the number of those referred to incidentally is far greater.

Coming from a man of such fine character, such wide experience in men and matters, and with such a trained hand in wielding the pen, these memories of great men are truly choice bits of literary fragments, warming the heart with a *personal* feeling of friendship for and acquaintance with the great men referred to, and regaling the mind with converse that must elevate the thoughts and inspire the soul.

The work is interesting from beginning to end, fascinating in many pages, and always delightful and entertaining reading. J. P. W.

Strategy, Grand and Minor Tactics. Thomas H. Barber, late Brigadier-General, U. S. V. New York: Circular No. 2, H. Q. National Guard, State New York, A. G. O., February 10, 1902.

General Barber has prepared a useful little paper setting forth the distinctions between the three subjects Strategy, Grand Tactics and Minor Tactics, and stating the most important principles of each. It is truly remarkable what he has been able to condense into 16 printed pages. Under strategy he gives a clear idea of the scope and general character of the subject, explains the principal kinds of decisive strategic points, and discusses the art of strategical combinations; under tactics the great principles are enunciated, the value of experience is pointed out, and a brief history of tactics is outlined, followed by a graphic picture of the tactics of today, and a detailed discussion of modern attack and defence in battle.

The little work should prove of great value to the National Guard, especially for the officers. J. P. W.

The Naval Annual, 1902. Edited by T. A. Brassey Portsmouth: J. Griffin and Co., 2, The Hard. New York: D. Van Nostrand and Co.

This reliable publication furnishes a review of the progress of the British Navy during the past year, showing that the rate of ship-building is improving and some of the lee-way made up.

The question of the personnel of the British Navy is dealt with by Lord Brassey; the necessity for making a serious attempt to develop an adequate Naval reserve is appreciated.

Submarine navigation is a question which receives special treatment in view of the large number of submarine boats built and building for the French Navy. So little reliable information has, however, been made public as to the purpose or results of the more recent trials, that the chapter on submarines is in the main limited to a description of the boats already in existence. Vision is given as the fundamental difficulty of submarine navigation; it is one which is far from having been satisfactorily overcome, and unless it is overcome, the hope is expressed that the Admiralty will not go beyond their present policy of building one or two boats a year. The menace of the submarine is far less serious than was the menace of the torpedo-boat ten years ago. The exaggerated importance attached to the latter has been proved over and over again in the maneuvers, and is now generally recognized.

Part II., Lists of ships, has received many additions.

Part III., Armor, Ordnance, and Gunnery is very suggestive. Among the Professional Notes in this number of the Journal will be found some interesting extracts therefrom.

Part IV., Naval Estimates of the Powers, has been supplemented by two strong letters by Lord Brassey on recent naual policy.

The present volume of this high-class publication maintains its position as the authority on the subject. J. D. B.

Trumpeters Hand-Book and Instructor. By William S. Littleton, Chief Musician, Fourth U. S. Cavalry. Hudson-Kimberly Publishing Company, Kansas City, Mo.

This little book neatly bound in leather, is designed by the author to secure uniformity throughout the Army in the sounding of trumpet calls and the ensemble playing of trumpet corps. The text is arranged in a manner so comprehensive that it at once appeals to the army trumpeter; commencing, as it does, with the first practical lessons for the trumpeter, it advances him, step by step, until it gradually develops him into a finished field musician. The instruction contained in this book for the ensemble playing of the trumpet corps is a want long felt in the service, and every trumpeter, who has an ambition to excel in his calling should be in possession of it.

T. V. T.

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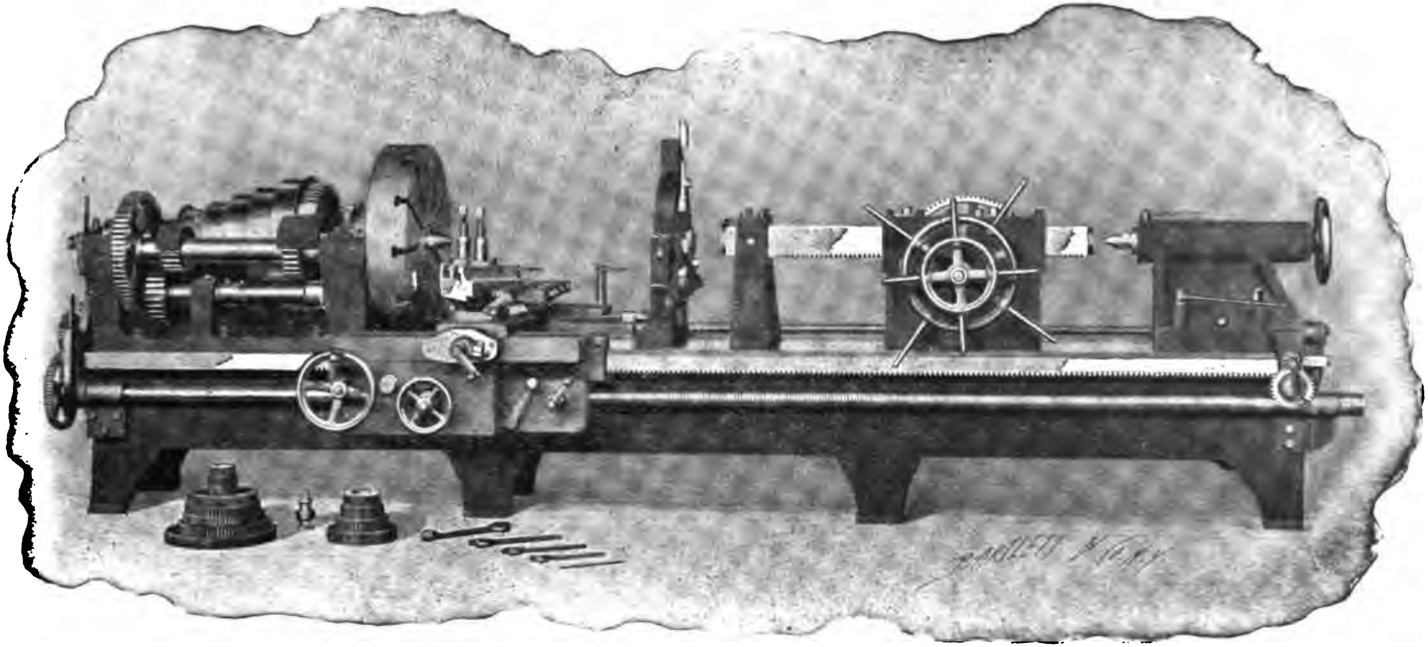

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